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ENGINEERING

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Leading Article
Hammer and Yardstick 321

Plain Words 322

Special Articles
How Good are Soviet Engineers? We can Learn Something from Them—and They from Us. 322
The Aircraft Industry: Guided Weapons Systems 349
More Power for the Technical Colleges 326

Letters to the Editor
Management and Bad Writing 325
Theory of Networks 325

Obituary
Dr. R. W. Bailey, F.R.S. 325

Companies in the News 326

Book Reviews
Science and Economic Development 336
Landslides in Clay 336

On the Shelf 336

New Books 337

Atomic Review
Power Plasma 347

Notices of Meetings 351

★ ★ ★

Metals and Materials
Raw Materials and Free Trade 327
Nimocast High-Temperature Casting Alloys 327
Low-Grade Iron-Ore Deposits 327
Uses of High Polymers 327

Plant and Equipment
The Engineering Exhibits at Olympia 328

Management
Weekly Survey 337

Marketing 338

Research and Development
Computing in the Modern World 339
Energy and Power Supply 341

Design
Data on Human Performance for Engineering Designers 344

Automobile Engineering
Influence of Tyres on Multiwheel Drives 348

Construction
Universal Floating Platform: Versatile Civil Engineering Units 350

The Human Element 352

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HAMMER AND YARDSTICK

THERE is a story about a diplomat who was noted for his unwillingness to commit himself on any issue. One day he was travelling by train with a colleague and saw from the carriage window a field of sheep. His companion remarked that the sheep had recently been sheared. "So it appears," replied the over-cautious diplomat, "at least on this side." In a two-week visit to the Soviet Union, one cannot hope to see all sides of Soviet industry, nor finally judge the quality of its engineers; but to exercise the reserve shown by this diplomat would be to limit one's report to such incontrovertible but useless details as: "Machine tools appear to be widely used in Soviet engineering works," or "Russian engineers are in general clean shaven and do not carry knives." It is therefore necessary to judge intuitively; to bridge the gaps between one's observations; and even occasionally to extrapolate. For this reason, any report must be subjective, and to get at the truth something must be said of the observer—and his yardstick.

Anyone visiting the Soviet Union from the West takes his prejudices with him. When he is told that the director of a factory knows less about engineering than his deputy, he may jump to the sinister conclusion that the director is a political boss, until he recalls that the chairmen of many British companies are also technically unqualified. The best starting point may therefore be to assume that the Russians are like ourselves and then to look for differences; rather than to suppose that they are different in some way, and to seek a few points of similarity.

Some re-orientation may be necessary. Thus the visitor may hear a successful candidate for admission to the Communist Party discussed with the same mixture of respect and indifference as we should display when referring to a Justice of the Peace. In the Soviet Union, Communism is orthodoxy, and the well adjusted, normally successful man is likely to be a Communist. Nevertheless, if he is a works manager or journalist, he will resemble an English works manager or journalist, rather than an English Communist. The visitor must also recognise a thousand new distinctions, learning for example that Kiev is no more in Russia than Glasgow is in England. It is also important, of course, to distinguish facets of Soviet society that are Communist from those that are simply Russian, Ukrainian or Uzbek.

Hospitality, for example, is an enduring Russian tradition. The visiting technical journalist is met with flowers, supplied with an attractive and devoted interpreter, established in a three-roomed hotel suite (complete with balcony and grand piano), and fed on caviare, smoked salmon and excellent Georgian wines. There will, of course, be vodka. Toasts will be drunk to unrefusable propositions, and the glass must be emptied on each occasion. After the third glass the journalist may find himself leaping up to propose in impeccable Russian the toast of heavy industry, only to realise that he has confused the Russian words for "heavy" and "jolly."

The journalist may suspect that such lavish entertainment is an attempt to suborn his judgment, but eventually he will realise that, governments and diplomats apart, people who wish to appear nice generally are nice. His hosts know in any case that once he is back in his own country they cannot affect his objectivity, even if they wished to do so. If Mr. Bonalevski chooses to show the visitor the Moscow subway, it is not because he wishes to create a false impression of grandeur, but because he is proud, and rightly, of a fine Soviet achievement; if he offers the parting guest a collection of long-playing records, it is because he desires to communicate an admiration for Russian music, not to seduce the listener. This is not unnatural; any normal person seeks to present a sympathetic view of his own country. Indeed, it is probably more fruitful to observe a strange country with a sympathetic open mind than with suspicion.

But in the last analysis, the journalist's suspicions can only be lulled by the opportunity to do his job. In the case of ENGINEERING's visit to the Soviet Union, the host journal, *Vestnik Mashinostroeniya*, and its representatives did their very best to provide this opportunity. We asked to see a particular range of industries, and apart from one that bordered on the military, we were allowed to do so. We asked to see a nuclear research establishment and a visit was arranged. We also asked if we could meet the internationally known Russian physicist P. I. Kapitsa, who worked with Lord Rutherford at the Cavendish Laboratory and had J. D. Cockcroft as his pupil. We repeated the request and towards the end of our visit it was granted.

But even if the industries are specified, the factories chosen may be show places rather than typical examples. Thus in one factory there was a workman wearing an enamelled badge marked "Good Worker"—in German. We were obviously not the first foreign delegation to visit the plant. But such factors can be taken into consideration. The article on page 322 is an answer to the question "How good are Soviet engineers?" It is a personal answer which, no doubt, will be interpreted differently by everyone who reads it.

Cover Picture. *British European Airways' brilliantly lighted hangar at London Airport is typical of the highly-organised maintenance engineering establishment essential to successful airline operation to-day. As in a modern factory, the shops are laid out for flow-line "production," and work is rigorously scheduled and planned in detail.*

* * *

Plain Words

In the streets around the offices of ENGINEERING the indigenous and continuous noise is of fruit and vegetable lorries, many of them with their engines so badly tuned that they have to be raced to prevent them from stalling. Occasionally a 4½ litre "vintage" Bentley, or a couple of street entertainers (one of whom makes great play with a fez), attracts the attention of, respectively, a discriminating minority or everyone with time to watch. Sometimes a fire engine scatters the loiterers as it rushes to an outbreak in Covent Garden Market; or a large cream ambulance cruises past, its subdued bell tinkling, on its way to Charing Cross Hospital. But the best sight to gladden the heart is a sombre brougham, the coachman up aloft and a mysterious passenger muffled up inside like dear old Mr. Lorry on the Dover Road more than a century and a half ago. The brougham is from the Royal Mews, and the mysterious passenger is on an important errand to a famous bank in the Strand. Not only visitors but Londoners, too, stop a moment to observe this unpretentious but immaculate turn-out. You can almost read their minds, as they stare wistfully until the noise of the hoofs has died away. "The atomic age can't give us that," they seem to say.

They are wrong; their sense of values is mixed up. It is true that one cannot get nostalgic about a 1957-model car, but then no one got nostalgic about hansom cabs when there were thousands of hansom cabs in the streets of London (except, of course, the old gentlemen who had romantic memories of youthful episodes). It is only when a particular type of vehicle or machine becomes rare that a breed of admirers is born. Thus, for example, an ancient taxi-cab which is to be seen in London to-day has had love and affection bestowed upon it. Painted in wild colours, it looks like something out of a circus, but the proud owner has added a domestic, aspidistra touch in the form of lace curtains and a notice with the words "Bed and Breakfast" hanging in a side window.

In the toolrooms and workshops there are men who cherish the lathes they have operated for years. They get quite cross when the plant engineer wants to install a new machine with all the latest refinements. Journalists and authors who prefer a typewriter to a pen become very attached to their well-worn machines, and yachtsmen who disdain motor launches derive considerable comfort from the little engine, tucked away below the cockpit, which can help them out as a rope helps a climber. Without doubt the day will come when a veteran computer will be treasured by its user; maybe, also, there will be a Society of Friends of Calder Hall, intent on preserving the structure or moving it to an enlarged Science Museum. But in spite of their magic to the lay mind, modern inventions have a long way to go before they compete in every respect with the old means of transport and production. There is no sign yet of a motor-car comparable to a horse which could pick its way across the Irish bog without a guiding hand, taking its master home after a Saturday night out in town.

HOW GOOD ARE SOVIET ENGINEERS?

We Can Learn Something from Them—And They from Us

Mr. E. P. Ward, M.A., A.M.I.Mech.E., a Deputy Editor of ENGINEERING, *recently returned from a two-week visit to the Soviet Union. He had the benefit of an interpreter but speaks some Russian himself, and was usually accompanied in addition by a Soviet technical journalist. He spent nine days in Moscow, where he visited a publishing house, the offices of a technical journal and the All-Union Standards Committee, a permanent industrial exhibition, a bearing factory, a special-steels plant, machine-tool and heavy-machine-building research institutes, and an automobile works. He had two excursions of between 50 and 100 miles from Moscow by car, first to the Joint Institute for Nuclear Research at Dubna, and later to the Soviet Academy of Sciences' experimental nuclear power station. While on a three-day visit to Leningrad, he inspected a turbine factory, a machine-tool building plant, and an electrical concern. In Moscow he also had an interview with Academician P. I. Kapitsa, the Soviet Union's best known physicist, who has recently made some important official statements on science and technology in* Pravda. *The first part of Mr. Ward's report appears below, and the leading article on page* 321 *comments on the circumstances of his visit.*

1—THE SOVIET ENGINEER AND HIS ENVIRONMENT

News filters through from what is to us the dark side of the earth, leaving us with mixed impressions of Soviet engineering skill. Visitors before the war returned with tales of technical backwardness—breakdowns, non-standard parts and confusion; now we have been shocked into a more respectful attitude by the news of a Soviet ballistic missile, the arrival in London of a fast jet passenger aircraft, and reports by British delegations that technical education in the Soviet Union is in some ways superior to our own. It has never been easy, but it is now almost impossible, to see Soviet engineering in perspective.

Recently we have heard much about the quantity, potential or existing, of Russian engineers; but what about their quality? After two weeks of intensive visits, and conversations with engineers, technical journalists, factory directors, works managers, research workers, representatives of ministries and the new economic councils, and also ordinary people, I have returned to England with a clearer picture of Russian engineering accomplishment. I believe that both Russia and the West can learn something from each other; that neither is pre-eminent. The present series of articles seeks to gauge Soviet success in various aspects of engineering work, while later articles will treat particular items in greater detail. Mr. A. A. Korolyov, deputy editor of the Soviet technical journal *Vestnik Mashinostroeniya* ("Mechanical Engineering Herald"), who is soon to visit this country, has agreed to prepare a reply.

Engineering in Soviet Life

To what extent do engineering products enter into Soviet life? As would be expected, Moscow and Leningrad are modern cities; the streets are crowded with motor-cars, sometimes of good contemporary styling, with a considerable sprinkling of elegant single-deck trolleybuses. A high proportion of the cars are large, suggesting that many are employed by officials rather than by private individuals. I was told that the use of official cars had been much abused until recently, so an order had been issued establishing central garages, from which officials might borrow vehicles for official purposes only. Further evidence that private ownership of road vehicles is comparatively rare is the small number of bicycles and motor-cycles to be seen on the Moscow streets and in the country, though I visited a factory where bicyles were produced (as a sideline) at a rate of two a minute (460,000 a year). Trams are still in use in Leningrad and the outer parts of Moscow; street lighting is adequate though not brilliant; and broad avenues minimise traffic bottlenecks.

Rail travel can be extremely comfortable, with well designed and equipped sleeping compartments. A 5 ft. rail gauge and a 16 ft. width of loading gauge permit generous carriage dimensions. Three trains run approximately simultaneously between Moscow and Leningrad several times a day, and to avoid the reactionary distinctions of first and second class, the coaches are denoted "soft" and "hard." Coaches are also set aside for children and those accompanying them. Long-distance trains are frequently steam-hauled, though Diesel and Diesel-electric locomotives are in use. The 100 km. track from Moscow to Dmitrov is electrified. A gas-turbine locomotive is said to be under development in Leningrad, and also a gas-turbine plant for marine propulsion. It has also been stated that a three-hour service between Moscow and London by the Tu 104 jet aircraft will come into operation next year.

Housing shortages in Soviet cities are a serious problem. While I was inspecting a full-scale model of a cabin for two sailors at the permanent industrial exhibition in Moscow, a voice from the crowd cried: "For two sailors? We have seven in a room like that." Nevertheless, the problem is being tackled with immense energy, and all round Moscow vast building projects are under way; large numbers of apartment houses of closely similar design and in various stages of completion are to be seen, and I counted 36 tower cranes in an area roughly that of Clapham Common. Many decorative and decaying wooden houses, particularly in the country, remain, but in a land where wood is an important natural resource this is not surprising. Non-condensing steam turbines (25 MW) are in operation as sources of power and secondary steam for process and district heating. A 50 MW version to supply areas 50 km. in radius is also in production.

Soviet engineers apply themselves enthusiastically to the entertainment and cultural industries. Even before the war, Moscow had a stereoscopic three-dimensional cinema. Polarised spectacles are not required and the screen appears to be a vast lens. The film I saw was a comedy, and the illusion of solidity was quite good, as soon as I learned to keep my head still. Even the ballet gave evidence of scientific accomplishment: at one point during *Swan Lake*, waves appeared to roll on to the stage so that the two principals were engulfed. The effect was entirely convincing and presumably achieved by air currents under a diaphanous floor cloth. Television is clearly a commonplace, though presumably only in the main population centres. As in Britain, aerials are legion; I saw eight on one large house and two on what appeared to be a signal box. I misquoted Lenin's famous dictum on religion, by remarking that "television is the opium of the people." At least one of my companions responded sympathetically. Excellent long-playing records are sold at a price half, if not a quarter, that obtaining in the United Kingdom.

There is a tendency to emphasise the post-Revolution growth of Soviet industry, which has certainly been great, but it must not be overlooked that Russian industry already existed long before the Soviets took control. Thus, the LMZ turbine factory in Leningrad is shortly to

Panorama of Moscow from the south. The view is taken from the Lenin Hills near the University, and some of Moscow's other six "skyscrapers" can be seen; all seven are of broadly similar design. In the foreground is the Central Lenin Stadium and on the right the Moscow River ski-jump.

celebrate its 100th anniversary, and the Electrosila works was once associated with Siemens Schuckert. The construction of vast trans-continental canal systems in Russia was discussed in ENGINEERING as long ago as 1897, and the Trans-Siberian Railway at the beginning of this century. Nevertheless, particularly in the field of capital development—roads, waterways, hydro-electric power and steelmaking—there can be no doubt that the Soviets have given a powerful impetus to Russian technical progress.

His Status

It is already well known that Soviet engineers occupy a high place in their community. Relative salaries provide a useful indication. A young diploma engineer, for example, will earn at least 880 and probably 1,000 roubles a month, which is equal to the salary of an experienced interpreter or a middle-school teacher working four hours a day. The lowest wage for a semi-skilled factory worker is about 650 roubles a month, though the minimum permitted wage is 370. The average monthly wage for workers in a particular automobile factory is 900 roubles; while in the same factory the average salary of engineers is 1,200 to 1,300 roubles, but with the upper grades receiving between 2,500 and 3,000. An engineer in charge of a shop may earn 2,000 roubles, and the head of a factory or a research institute between 4,000 and 6,000. A doctor of science is entitled to 1,000 additional roubles a month, and a candidate of science, the next lower degree but above the qualification of diploma engineer, 500 roubles a month. The head of the heavy-machine building institute, who is a doctor of science, earns 6,000 roubles a month; he remarked that he had recently visited England and that his opposite number there seemed to have roughly the same living standard. A teaching professor of medicine would earn roughly the same. There are also bonus payments in cases where a norm is exceeded. Some guide to the purchasing power of such salaries may be gathered from the accompanying table of prices.

Approximate Prices of Commodities in U.K. and U.S.S.R.

Commodity	U.K.		U.S.S.R. (roubles)	
	Upper	Lower	Upper	Lower
£1 Sterling ..	—	—	26 (tourist)	11 (trade)
lb. butter ..	3s. 6d.	3s. 2d.	10	—
lb. apples ..	2s. 0d.	5d.	3	1
Suit	£40	£7	1,200	300
Brandy ..	36s. 0d.	—	50	—
Car	£884 (Morris Oxford)	£625 (Morris Minor)	20,000 (Pobeda)	15,000 (Moskvich)
Upright chair ..	£12	£3 10s.	30	10
Long-playing record ..	£2	—	10	—

It is significant that there has been little change in prices in the Soviet Union over the last five years, except, it is claimed, for a gradual decline.

Recent political developments may add to the status of the engineer; in particular, the movement towards decentralisation and the independence of scientific and technical workers. Many engineers have two jobs; thus the head of the instrument department of ENIMS, the machine-tool research institute, is also editor of the journal *Machine Tools and Instruments*, though this is regarded simply as "social" work; similarly, the editor of *Vestnik Mashinostroeniya* is also chairman of the All-Union Standards Committee. To adopt a Western criterion of status, I noticed that the chief technologist of a large factory (not to be confused with the chief engineer, who is concerned with production rather than processes) and the director of another each had four telephones. Incidentally, the status of tenors appears to be rather higher; I saw the large riverboat that one of them had hired for his daughter's honeymoon.

His Place in Industry

The status of an engineer is likely to reflect his value to society, and his value will depend on the use that can be made of him. How profitably are engineers employed in the Soviet Union? Are they sometimes wasted? When an engineering student obtains his diploma he is normally directed to appropriate employment, but if the post proves to be unsuitable he can choose a new appointment. Nevertheless, the rate at which engineers are produced and the tendency, whatever the job, to prefer an engineer to a technician, and a technician to a craftsman, must lead to some misplacing and under-utilisation of qualified men. The unbalanced distribution of different grades of labour is illustrated by the shortage of unqualified workers. I was told that it was frequently necessary to

The Pavilion of Mechanical Engineering is one of 21 at the permanent industrial exhibition in Moscow. Though many pavilions are built in ornamental style, the exhibits are presented in a contemporary manner. Exhibits are periodically changed and include many experimental items.

Milling both faces of a Kaplan turbine blade simultaneously in the LMZ turbine works at Leningrad. Special-purpose machine tools and large-scale plant are characteristic of Soviet engineering practice.

offer labourers living space and sometimes higher wages than trained men, because those willing to perform manual work were in such short supply. The remarkably high proportion of engineers on factory staffs bears out this conclusion, though it also underlines the extent to which research is carried on in factories. The table below gives stated figures for diploma engineers, technicians and total number of employees in various factories and research organisations.

It is clear from these figures that the term diploma engineer has in the Soviet Union a somewhat different meaning from engineering qualifications in this country; but the extremely high percentages are nevertheless of great interest. As a basis for comparison, the number of professional engineers, diploma engineers and holders of Higher National Certificates in selected British industries can be given as percentages of total employees. Thus in the electrical industry there are 2·8 per cent.; in the iron and steel industry 0·65 per cent.; and in the motor vehicle industry 0·87 per cent. It is significant that the Soviet electrical factory likewise has the highest percentage of qualified employees. Foremen are frequently diploma engineers, but unqualified men often hold positions of greater responsibility than diploma men.

At the steel factory, where 10 per cent. of the staff are engineers or metallurgists, I was told that at more modern metal factories, as in the Urals, the proportion of qualified men was lower. It is also of interest that university lecturers and professors often serve as consultants to industrial firms.

Of special interest is the high proportion of diploma engineers who are women. In fact the Soviet Union almost manages to double its labour force per unit of consumer population by the widespread use of female labour and the provision of crèches for children. Often the care of children is the responsibility of the factory, and the ZIL automobile works has three children's summer villages, all between 40 and 70 km. from Moscow. Of the 450 engineers and technicians at the First State Ball Bearing Factory, some 40 per cent. are women, working mainly in the estimating, costing, and work-study departments. The majority have diplomas in engineering economy, which are of comparable standing with engineering diplomas and awarded by an institute. At the Electrosila factory in Leningrad, 300 of the 1,000 diploma engineers are women.

Post-diploma studies are generally carried out in the evenings, but for those able or willing to

Lenin's words are widely quoted, often as a guide to action. This poster is in the forecourt of the Electrosila factory in Leningrad and states: "Communism —it is Soviet power plus electrification of the whole country. V. I. Lenin."

Long before the Soviets came to power, Russia had an engineering tradition. "Tsar Kolokol," believed to be the largest bell ever made was cast in 1733 and weighs 180 tons. Behind is Archangel Cathedral in the Kremlin.

Tractors have long been associated with the Soviet economy, and are now made in a variety of special and general-purpose designs. The DET 250 has a Diesel-electric power unit.

Engineers and Technicians in Factories and Research Organisations

Organisation	Total employees	Engineers	Technicians and draughtsmen
Bearing factory	10,000	450 (4·5 per cent.)	
Special-steels plant	10,000	1,000 (10 per cent.) (including metallurgists)	
Turbine factory	11,500	1,000 (8·7 per cent.)	2,000 (17 per cent.)
Electrical generator factory	6,000	1,000 (17 per cent.)	2,000 (33 per cent.)
Machine-tool plant	2,500	300 (12 per cent.)	140 (5·6 per cent.)
Motor-vehicle factory	40,000	6,000 (15 per cent.)	
TSNITMASH (heavy engineering research institute)	4,000	860 (21 per cent.)	—
ENIMS (machine-tool research institute)	2,450	850 (35 per cent.)	

It should be noted that the staffs for the two research institutes include workers in various associated plants. The figures given also include senior engineering qualifications—doctors and candidates of science, in addition to diploma engineers.

The GAZ M21 "Volga" with binnacle speedometer panel and modern styling illustrates the Soviet desire to keep abreast of current design. The front and back seats may be adjusted to form a bed.

Determination to foster public interest in engineering work is indicated by Moscow's industrial exhibition, which is built partly as a pleasure garden. Each statue on this fountain, 15 in all, has a coat of gold weighing 100 gm.

sacrifice their incomes, day courses are also provided. To encourage the engineer to continue his education, there are a series of further qualifications. On obtaining his diploma he must complete three years of useful work, following which he can become an " aspirant " by joining a special school. There he spends two years preparing for examinations and a third working on a thesis. At the end of the third year he presents his thesis and defends it publicly before a scientific panel. If successful he becomes a Candidate of Science, the first engineering degree. The Candidate may then prepare a doctor's thesis on some salient problem (for example, the design of industrial rolling mills), presenting it after perhaps five or ten years to become a Doctor of Science.

As has already been suggested, the engineer is not entirely a free agent, but there is a tendency at present to give him increasing liberty of action. Academician P. I. Kapitsa, in a recent statement in *Pravda*, suggests that " the more independence and initiative a man has on his job the greater his productivity of labour in comparison with that of a worker whose cultural level allows him to do a good job only when he executes detailed directives handed down from above." But subsequently he writes: " It is necessary to foster and stimulate in our scientists and some foremost engineers a sense of mobility." No doubt, given efficient administration, it is quicker to direct the engineer to the point where he is required than to wait for the operation of an economic mechanism.

Some problems are the same the world over. A recent decree states that the newly qualified engineer should begin his working career as a " master " or foreman. The result of placing a young graduate over experienced men is well known, and in Russia, too, the men try to catch him out; in the words of one factory director they " look for his weak points to bite him."

His Tastes

It is often supposed that the Russian is old-fashioned. His tastes in literature are nostalgic; his buildings are ornamental; and his paintings display a photographic realism. We are not surprised to find fluted columns in his high-speed aircraft or oriental carpets in his taxicabs; even a nuclear power station with a classical façade does not seem out of character. But appearances can be deceptive. Inside the carved pavilions of the industrial exhibitions are modern machines effectively presented. The elaborate exteriors are residues of a passing generation; inside are found the fresh contemporary styles of their successors.

It has been suggested that the revolutionary generation sought to give universal access to the styles admired by tsars and boyars, forgetting that tastes change.

In contrast to public grandeur, personal chic is largely disregarded. Russians of the older generation, even of quite senior rank, seldom wear ties—at least in summer—nor are they concerned to arrange their collars neatly. Even in a downpour, few raincoats are to be seen. There is no-one corresponding to our smart city man with his rolled umbrella and bowler hat. Yet every Moscow Metro station is as splendid as an opera house, expensively wrought and perfectly kept; the streets are clean, historic buildings are beautifully restored and tsarist treasures lovingly preserved. It is clear that in the Soviet Union pride of community comes before pride of person.

Although there are still those who express a preference for " the age of candles and carriages " to that of aeroplanes and atom bombs, the Soviet Union's bright young men have much in common with their contemporaries elsewhere. Russia even has an expensive version of the Teddy Boy—the " Stilyagin." Taste is mixed as it is here: Russians may scoff at modern art but so do correspondents to the *Daily Telegraph*. Official art is heroic, but there are Russians who prefer their art to be unheroic.

Letters to the Editor

MANAGEMENT AND BAD WRITING

SIR, Rhythm, poetry and lengthy *explicit* words do not, as your correspondent Mr. A. Battersby implies in ENGINEERING of August 23 (page 228), defeat the object of clarity in technical writing.

If he doesn't give his foremen clear orders " they muck things up," he tells us. Why sacrifice clarity to vulgarity ? " Do things wrong," if he insists on brevity, is quite as satisfying as " muck things up." Any foreman worth his salt would be likely (and quite rightly so) to resent a vulgar approach where his orders are concerned.

Eloquent padding, in moderation, makes for readability but it is, of course, important to know where to draw the line and this is a point on which no two individuals agree. Some people would take exception even to your correspondent's embellishments " *lilting* rhythm," " *Lorelei* spell," " *enchanting* trochaic."

We are all surrounded by glass Mr. Battersby, and there are many stones to be thrown !

Yours sincerely,

EDRIC HIGGINBOTTOM.

Greystone Cottage,
Hathersage.
September 2, 1957.

★ ★ ★

THEORY OF NETWORKS

SIR, Thank you for reviewing my book *The Theory of Networks in Electrical Communication and Other Fields* in your issue of August 9, page 180. While the reviewer's comments are, in general, much valued, I respectfully submit the following observations on certain of his statements that I think to be erroneous, or else misleading.

A re-examination of chapter 10 will show that insertion loss is discussed in general terms as well as in terms of image parameters. Examples not involving image parameters will be found on pages 395 to 398, 401 to 403, 421 to 431, and elsewhere. Although the traditional formula in terms of image parameters, reflection factors and interaction factor is derived, the disadvantages of such an involved formula are commented on (as, for example, on pages 395 and 401).

The connection between the time and frequency responses of a network is, in fact, pointed out, through the medium of the Fourier integral (page 59). It is recognised, however, that this topic might have been carried further.

It is misleading to suggest that insertion loss has been accorded secondary importance in relation to filters. Although the treatment is confined to basic principles in terms of image parameters, much attention has been paid to insertion-loss characteristics. Reference should be made, for example, to Fig. 11-4, on page 439, and to pages 445 to 455. The approaches aim at answering many questions that the image basis of design arouses in a student's mind.

No doubt the reviewer is thinking of the insertion-parameter method of filter synthesis, exemplified by Darlington's approach. The advantages of this over the image approach are mentioned on page 490. The principles of the image approach nevertheless remain important, and must be explained to students: the desirability of attempting to précis the details of a theory, so important yet so involved as Darlington's, is, therefore, debatable in the case of a book not specifically intended for the filter specialist.

Perhaps, in speaking of confusion between image and characteristic impedance, the reviewer is basing his remarks entirely on the introductory statement which commences section 3 on page 372, but it is difficult to see how this statement, when associated with the definition, diagrams and analyses that follow, can cause any confusion.

The design of an asymmetrical network to have specified image impedances and image transfer constant is certainly dealt with, but by a method which, it is hoped, may prove clear and simple (page 387). It is the author's opinion that the asymmetrical network has no natural association with a recurrent structure, as in the case of a symmetrical T or π network, and it is questionable whether any advantage in clarity is gained by treating it in an iterative way.

Unless matrices are to be used by rule and without understanding, it is first necessary for the student to grasp the ideas of using compact systematic notations in equations, and the generalisation of solutions. Developing the double-subscript notation, and demonstrating solutions in compact general forms by means of determinants, is surely not in conflict with the requirements for a subsequent study of the even more compact, flexible and comprehensive treatment of networks with matrix algebra.

Other valuable comments, particularly those relating to omissions, are noted and will certainly be borne in mind for a future edition.

Yours faithfully,

F. E. ROGERS.

Forest Hill,
London, S.E.23.
September 4, 1957.

★ ★ ★

Obituary

DR. R. W. BAILEY, F.R.S.

Metals at Elevated Temperatures

News of the death of Dr. Richard William Bailey, which occurred on September 4, will be received with regret by engineers in many parts of the world. Dr. Bailey will always be remembered for his researches on the strength of metals and alloys at high temperatures, and it was only on March 31 of the present year that he had retired from active duties as consultant to the research department of the Metropolitan-Vickers Electrical Company, Limited.

Born on January 6, 1885, Bailey served an apprenticeship to mechanical engineering at the Stratford Locomotive Works, London, of the Great Eastern Railway Company. In 1903 he obtained a Whitworth Exhibition and attended Queen Mary College (then known as East London College) as a director's scholar. He gained a Whitworth Scholarship in 1905 and held this partly at the City and Guilds Central Technical College and partly as an electrical-engineering college apprentice with the British Westinghouse Electrical Company (now the Metropolitan-Vickers Electrical Company) which he entered in 1907. Making a temporary break with industry, Bailey became a lecturer in mechanical engineering at the Battersea Polytechnic, London, in 1908, and four years later, was appointed the first Principal of the Crewe Technical Institute.

In 1919 Bailey returned to the Metropolitan-Vickers Company to take charge of the laboratories in the firm's research department. During the years which followed he and his colleagues and assistants established a reputation for careful experimental work on the behaviour and operation of materials at elevated temperatures and high stresses, and contributed to the progress made in the use of special steels for steam turbines and other power plant. In 1945 he relinquished executive duties to give more attention to special research and development work and to act as consultant to his firm's research department.

Bailey, who was awarded the Thomas Hawksley Premium of the Institution of Mechanical Engineers in 1929 and the Thomas Hawksley Gold Medal in 1935, was made a D.Sc.(Eng.) of the University of London in 1936. For his research work Bailey was elected a Fellow of the Royal Society on March 17, 1949. Joining the Institution of Mechanical Engineers as an associate member in 1922, he was transferred to the class of member in 1936, was made a member of the Council in 1942, a vice-president in 1949 and was elected president in 1954. Dr. Bailey served as president of the Whitworth Society from 1955 to 1956.

MORE POWER FOR THE TECHNICAL COLLEGES?

Giving his presidential address to the Engineering Section of the British Association's Dublin Meeting last week, Sir David Anderson, Director of the Royal Technical College, Glasgow, said that no single step would produce greater results, in encouraging young people to choose technology as a career, than the conferment of degree-granting powers on some of the leading technological institutions of Britain. "We are the only industrial country," he said, "in which the leading institutes of technology do not have full university status and in no other country is the output of engineers so small. I, personally, see a close connection between the two."

Referring to the comparative figures for output, he said "valid comparisons are difficult to draw, but from all the information available it seems that Russia, the United States, Western Germany, and Britain are producing technologists, mostly engineers, in the ratio of 4 : 2 : 2 : 1 per unit of population. The conditions in Russia and the United States are very different from those in Britain, but with Western Germany we have much in common. The population of the two countries is the same, we are both at the same stage of industrial development, we are both heavily dependent on exports, and I find it more than a little disturbing that they are producing twice as many technologists as we are."

Sir David remarked that engineering education is a subject on which it is difficult to say anything new, but he made a number of points which were characteristically stimulating. The chance of securing 20,000 graduates in science and engineering in the next ten years seemed slender, he said. There would undoubtedly be some increase in output both from the universities and the technical colleges, but he was fairly certain that the major increase was going to come from the technical colleges. These institutions were all linked with the great stream of part-time education, and it was in that stream that there was an appreciable reserve of good brain-power which could be picked out and transferred to full-time courses. He believed that the research scientist would remain a university product, but the development engineers and designers and the production engineers and managers might be educated either in the universities or in the colleges of advanced technology or in some of the regional colleges.

As to a measure of liberal studies, his preference was for some attempt to teach the writing of good English, some lectures on logic as an aid to clear thinking, something about the history of science and industry, something about psychology as it bears on our thinking processes and group reactions, and something about philosophy and values. For management studies undertaken at the postgraduate stage, he thought the ideal arrangement was a planned series of short residential courses spaced throughout the earlier years of a man's professional life. "In the hustle and bustle of industrial life there is just no time for reflective thought and unless opportunities are specifically provided, creative thinking about one's job goes by default." As regards the apprenticeship system, Sir David said "It is disturbing to reflect that in Britain a youth can become a skilled craftsman without having attended a single class or passed a single examination in the whole five years of his apprenticeship."

Of the several proposals put forward by Sir David, that on the application of work study to learning seems to have attracted most attention. "Much research," he said, "has been done on the learning process and teaching methods at the infant and primary stages, but, so far as I know, nothing much has been done at the undergraduate level. Is it fantastic to suggest the application of some kind of 'work study' to mental processes in the same way that work study is now applied to physical processes with excellent results?"

Companies in the News

Better to come from G.E.C.

The outlook of electrical engineering concerns continues to improve. Two weeks ago the directors of A.E.I. announced with their half-year's results (to June 30) that the intake of orders had risen sharply. Now Sir Harry Railing, chairman of the General Electric Company, speaks of the future in terms of expansion. His company has spent £2 million, mainly on plant and machinery, in Great Britain alone, in accordance with their policy of adding substantially and regularly to their productive capacity. The electrical industry, according to Sir Harry Railing, is "on the threshold of further expansion," He, like Lord Chandos, considers that electrification is synonymous with rising living standards—in fact, that electrical energy is "the fundamental factor in the dynamism of economic betterment."

G.E.C. recorded a 10 per cent. increase in output, but profits at £9·6 million, remained substantially the same as in the previous year (£9·8 million) and in 1955 (£9·9 million). It has been found very difficult to raise prices, particularly abroad, without affecting the volume of sales. Sir Harry Railing states that G.E.C. aim to counteract the shrinkage in profit margins, "first by reducing production costs through more economic design, less costly materials and more economic production methods, and second by a larger volume of sales."

There is plenty of evidence in this long and detailed review that the difficult time which all big electrical engineering companies went through last year has given way to somewhat easier conditions. But this is an industry where there is a low degree of concentration, compared with either the United States or Germany. The passing of the Restrictive Practices Act may, as Sir Harry Railing points out, prevent companies from earning sufficient profits "to keep up the effort required for research, engineering development and modernisation." For this company, and several others, good profits in this type of activity are essential to finance research and development in the field of nuclear energy more than in any other.

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Outlook for Constructional Engineering

Companies engaged in structural steelwork should not lack orders in the next 12 months or so. In fact, during that period the shortage of heavy rolled-steel products is likely to limit output. Two companies engaged in producing equipment and structures for the building and civil engineering trades, the Horseley Bridge and Thomas Piggott group and Acrow (Engineers), both report very satisfactory order books and good conditions for further expansion.

The excellent results of Acrow—group trading profits have expanded by about 12 per cent. during the year ending March 31—have been assisted by the development of overseas interests. Important contracts, such as shuttering and formwork for the Beauharnois lock on the St. Lawrence Seaway project and shuttering for the Kariba power station in Rhodesia, are typical of the expansion of the group's interests overseas. The Horseley group also succeeded in raising their trading profits, by 15 per cent., despite what their chairman, Mr. John Sheffield, describes as "most difficult trading conditions reflected by shortages in material supplies and a continuous rising spiral of costs outside our control."

The Horseley group have a major proportion of their capacity taken up by heavy steel fabrication, including gasworks, chemical and boiler plant, general tank work, welded pipe work and heavy iron castings as well as a wide range of structural steelwork. Provided steel can be obtained—and in this case heavy plate is essential—there is plenty of work to be found. While hesitating to forecast the future during a period of "apparently uncontrollable inflation," Mr. John Sheffield reports "a record list of orders in hand which will keep our works and erection sites very busy for a considerable time." The likely acquisition of Mechans Limited, of Scotstoun, Glasgow, with "extensive fabricating facilities in their modern works of 18 acres on the Clyde and a sizeable steel quota" will greatly strengthen the group's export potential owing to its very good shipping facilities.

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Radio and TV Sales

For some time now Pye have been absorbing increases in costs, to some extent by increasing efficiency, but also at the expense of profits. Now Mr. C. O. Stanley has said that "the time is rapidly approaching when we will have to pass on wage increases to the public." This is quite a departure for this very determined company which has, since the war, pursued a policy of rapid expansion and of all-out attack on export markets. One of the reasons could be that demand for their products has hardened recently. In the first seven months of this year sales of radio sets rose from 502,000 in the first seven months of last year to 610,000; sales of television sets rose from 492,000 to 555,000 and those of radiograms from 94,000 to 124,000.

The effect of this considerable improvement on the industry will provide a welcome relief from anxiety. G.E.C., whose sales of television sets in the year to March 31 were a record, intend to expand further into this market and have already arranged to increase output. There are doubtless a good many difficulties to be overcome before reasonable stability is reached but equally there is increasing confidence that the trend of demand is sharply upwards. As Mr. H. Amelan, chairman of Outram (Investments) pointed out to his shareholders, there is room for confidence that "looking to the future, more normal trading conditions will lead to substantial development on the fine conditions already existing."

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Exceptional Margins

The results of George Cohen provide a good example of success not only in maintaining profit margins but in increasing them. In the year to March 31, turnover rose by 25 per cent. to £32 million, and trading profits by 27 per cent. from £1·79 million to £2·28 million. This rate of profit, which represents 23 per cent. on a capital of £10¾ million, is outstandingly good. The 600 Group make a wide range of engineering products, including cranes, machine tools, precision bearings. They are civil engineering contractors, metal and scrap-metal merchants, contractors' plant hirers, etc. They doubtless owe much of their profits to the strong demand for steel. But much also has been due to good organisation and management. The remarks of Mr. Cyril Cohen, chairman of the company, on the manner in which K. and L. Steelfounders and Engineers have managed to do well despite set-backs in the steel foundry division (due to the almost complete cessation of defence orders early in the year) shows how the 600 Group have earned a high profit ratio: "we have developed over a number of years a very successful budgetary and costing system. Within four working days from the end of each four-weekly accounting period, trading results and other statistics, including information on such matters as the effects of rising costs and similar data, are available. Thus knowledgeable decisions affecting policy can be taken promptly."

Metals and Materials

RAW MATERIALS AND FREE TRADE

Dutch pressure in the Free Trade Area negotiations is increasing to include agriculture. At first sight this appears as an intransigent attitude towards the British point of view of imperial preference for foodstuffs and the production of domestic agriculture. There is something in this, but the Dutch have their eyes to the south, mainly in the direction of France rather than across the North Sea to the United Kingdom.

Even before the treaty of Rome was signed the Netherlands were determined that the new economic concert of Europe should not become a high-tariff area for the benefit of French agriculture. They were equally sure that they would not countenance a broad definition of foodstuffs when agriculture was discussed so that high tariffs should be imposed on certain imported raw materials on which Holland is dependent for its industries. The Dutch are basically in favour of the Free Trade Area. Their wages in many industries are comparatively low and their social service charges are also lower than those of France and Belgium. They have had some experience of the Benelux tariff arrangement which has given them some evidence that they can live with higher-cost countries and penetrate their markets without causing a panic in the higher-cost country. Nevertheless, they do not wish their initial tactical advantage of low costs to be offset by evasive treaty drafting which will put them at a disadvantage so far as raw materials are concerned.

The recent speculation on the Continent which centred on the Deutschmark also had repercussions on the Dutch guilder. In consequence they are alerted to some of the problems which may face a fairly strong economy once a common market or a Free Trade Area becomes established. The Dutch are aware, too, of their own balance of payments difficulties which have been increasing of late. Altogether, the Dutch are not in a mood at the moment to give much away in the interests of European economic unity, but the mood may pass.

NIMOCAST HIGH-TEMPERATURE CASTING ALLOYS

The name " Nimocast " has been introduced by Henry Wiggin and Company, Limited, Wiggin-street, Birmingham, 16, to cover a range of high-temperature nickel-chromium-base alloys for use in the cast forms. Six alloys are now available in the series and five of them were developed in the laboratories of the Mond Nickel Company, Limited.

The Nimocast alloys are complementary to the Nimonic series of wrought heat-resisting alloys and some of the former were previously included in the Nimonic series. Others were known by laboratory designations.

The first of the six new alloys, Nimocast 75, was formerly known as Nimonic C.75. It may be used under conditions involving low stresses but requiring good resistance to oxidation. The alloy does not respond significantly to heat treatment and is normally employed in the as-cast condition or after a stress-relieving treatment.

Nimocast 80, formerly designated Nimonic CC and corresponding to Nimonic 80, possesses considerably higher room-temperature mechanical properties and creep-resistance than Nimocast 75. It is used for gas-turbine stator blades and pre-combustion chambers of high-performance Diesel engines. The alloy is normally used in the fully heat-treated condition.

Nimocast 90, formerly Nimonic CB and the casting version of Nimonic 90, also responds to heat-treatment and is generally used in the age-hardened condition. In general, Nimocast 90 is to be preferred to Nimocast 80 for high-stress high-temperature applications in view of its better " castability " and superior strength. At 750 deg. C., Nimocast 90 shows stress-carrying capacity inferior to that of the corresponding wrought alloy, but at 870 deg. C. and above, Nimocast 90 carries at least as high a stress for a given " life " as Nimonic 90.

Nimocast 242, formerly C. 242, was developed by Rolls-Royce Limited for investment-casting applications involving high resistance to thermal shock. It is used in the as-cast condition at temperatures of up to 1,050 deg. C. for such components as stator blades for gas-turbine engines.

Nimocast 257, formerly MC.57, has properties intermediate between those of Nimocast 75 and Nimocast 90, giving adequate proof stress, combined with good ductility, at temperatures in the range 600 to 700 deg. C. It is used in the fully heat-treated condition and is of particular interest for centrifugally-cast rings used in gas turbines.

The last of the series of six alloys, Nimocast 258, formerly MC.58, is a recently developed material having good stress/rupture properties at temperatures higher than 950 deg. C. It is similar in composition to Nimonic 100, the most creep resistant of the Nimonic series. This alloy has the highest stress/rupture properties in the as-cast condition.

All six alloys are available for re-melting in the form of cast stick or foundry pig and as will have been seen offer a wide range of properties for many engineering applications requiring high resistance to oxidation and thermal shock, together with high tensile and stress/rupture properties.

LOW-GRADE IRON-ORE DEPOSITS IN MINNESOTA

Minnesota is a State which, for a considerable time, has provided the blast furnaces of the United States with large quantities of high-grade iron ore. Now, however, these resources are reaching exhaustion and attention is being turned to alternative sources of ore. There are in Minnesota large quantities of low-grade ore which, containing from 25 to 30 per cent. of iron only, have proved uneconomical to mine and transport hitherto.

This material exists in huge quantities and is known as taconite. At the present time large plants are being constructed to process the ore and produce pellets having an iron content in the region of 60 per cent.

Three companies are engaged in this work, namely, the Erie Mining Company, the Reserve Mining Company and the Oliver Iron Mining Division of the United States Steel Company. The capital invested by Erie is in the region of 300 million dols. and when their plant comes into production it will turn out 7½ million tons of pellets every year. The production of enriched taconite pellets has already commenced from the plant of the Reserve Mining Company and it is expected to reach 3½ million tons yearly from a plant which has cost 190 million dols. The third concern, the Oliver Mining Division, has completed a small pilot plant and is carrying out experimental work to determine the most economical processing methods.

Unlike the Reserve Mining Company, the Erie Mining Company are processing their material close to the mine and at the present time they have under construction, at Aurora, on the eastern end of the Mesabi Range, one of the largest ore-processing plants so far constructed on one site. When work is completed the company will have constructed a new town, a 73-mile long railway connecting the processing plant to a new harbour, and other large ancillary works.

The first step in the preparation of taconite pellets is the preliminary grinding of the rock which is mixed with water in grinding cylinders. After this, magnetic separation is applied. Further grinding then takes place and by successive screening and the rejection of oversize material the taconite is reduced to very fine particles and the final application of magnetic separation leaves 60 per cent. of iron in the material. Subsequently, de-watering is carried out and when the moisture content is reduced to 10 per cent., bentonite and finely powdered anthracite are mixed in and the whole rolled into balls of between ¾ in. and 1½ in. diameter. Firing produces hard pellets ready for transportation to the blast furnaces.

Manufactured pellets can be loaded directly into railway trucks for removal to the blast furnaces by way of the Great Lakes. During the winter months when the Great Lakes are closed to navigation the pellets are to be stored for subsequent collection and removal.

The decision to transport the ore by rail to the shore of Lake Superior and then send it by ship through the Great Lakes to the blast furnaces made it necessary to construct a harbour on the lakeside, as near as possible to the iron-ore mines and the processing plant. Fortunately, almost directly east of the plant there are two islands about 1,500 ft. offshore which, now connected by a breakwater, have formed a good harbour. At this site, known as Taconite Harbour, high-speed loading facilities have been installed together with railway handling equipment which is expected to load the ore-carrying vessels in record time.

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THE USES OF HIGH POLYMERS

Important advances are now being made in the theory and practical applications of high polymers, and the subject appears to be undergoing one of those periodic transformations that are common to most branches of science. In order to provide an appropriate opportunity for a full exchange of views between scientists and others interested in this field, whether engaged at the universities, research establishments or in private industry, an international conference is being held at Nottingham University from July 21 to 24, 1958, under the auspices of the Macromolecular Commission of the International Union of Pure and Applied Chemistry. The conference will have two main themes: Section A, reaction mechanism and kinetics, including heterogeneous polymerisation and the production of graft and block co-polymers; and Section B, physical, thermodynamic and mechanical properties.

It is intended that about 20 papers describing original work in each of these sections shall be presented in brief, in order to allow adequate time for discussion: copies of the complete papers being available in advance. Arrangements are in the hands of a British committee, acting under the chairmanship of Dr. H. W. Melville, F.R.S., and further information may be obtained from Mr. R. G. Silversides, M.Sc., International High Polymer Conference, Charles House, 5-11 Regent-street, London, S.W.1.

The membership fee, including preprints and light refreshments, is £3 10*s*. and the accommodation fee, including board, is a further £3 10*s*.

Plant and Equipment

THE ENGINEERING EXHIBITION

Third Article

This, the twenty-first exhibition in the series, closed on Thursday, September 12, after its fortnight run. The next in the series will bear the same title—Engineering, Marine, Welding and Nuclear Energy Exhibition—and will be held in 1959. There is, however, one big change—it will be a spring show, held from Thursday, April 16, to Thursday, April 30.

HALOGEN LEAK DETECTION

Among the exhibits on the stand of the British Thomson-Houston Company, Limited, Rugby, is a portable leak detector. The equipment will detect the presence of very small traces of halogens or halogen compounds in the atmosphere. It is immediately applicable to refrigerating systems—these already contain a halogen compound—and may be used on other systems—tanks, pipes, pneumatic devices—by injecting a small amount of carbon tetrachloride as a tracer.

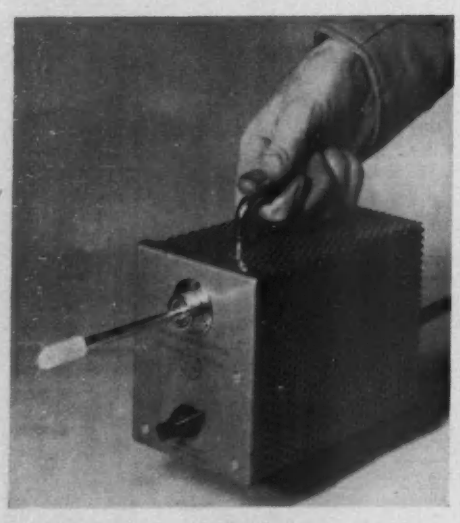

Fig. 43 Detection of halogen gases present at densities as low as a few parts in a million is possible. British Thomson-Houston Co., Ltd.

The leak detector does not measure the leak rate, but it is sensitive enough to detect a leakage of Arcton (dichloro-difluoromethane) at the rate of 0·05 oz. per year. Among the applications that have been found are the testing of underground cables, refrigerators, aircraft control systems, and tinned-food cans.

Various types of detector are made. Shown in Fig. 43 is the type HMB, which operates from a 6-volt car battery. Because all types use a mode of operation that entails the passage of a sample of the surrounding air over a platinum electrode heated to 800 deg. C., the instrument must be regarded as a "naked flame," and must not be used in the presence of inflammable vapours. The detector operates by virtue of the fact that an increase in the halogen content of the surrounding air causes a corresponding increase in the emission of positive ions from the heated platinum electrode. The sensitive element consists of a pair of concentric platinum cylinders in a glass envelope. In operation the air to be sampled is drawn by a fan through the annular space between the cylinders. The inner cylinder is the anode. It is raised to its working temperature by an internal heater.

With an anode-to-cathode potential of 250 volts, only a very small positive ion current flows under clean air conditions. But immediately air containing halogen vapour is drawn in, the positive ion current is increased. In the type HA detector, the change of current is amplified and indicated on an output meter; at the same time a loudspeaker is actuated causing a change in the rate of the signal clicks—in operation the instrument sounds much like a Geiger counter. In the types HM and HMB, the increase in positive ion current triggers a thyratron which in turn operates a buzzer. Thus audible indication is only given when a leak is detected.

DYNAMIC BALANCING

The vertical single-plane dynamic balancing machine exhibited by W. and T. Avery Limited, Soho Foundry, Birmingham, 40, is designed not only to indicate the magnitude and angular position of dynamic unbalance, but is also equipped with a drilling unit, which enables corrections to be made on a test rotor without removing it from the machine. It is suitable for use with narrow rotors (flywheels, for example), up to 35 lb. in weight and 15 in. diameter. A suitable fixture for carrying the rotor on the test spindle must be provided by the machine user; a foot-operated quick-release device is incorporated so that a collet-type fixture can be used when the design of the test rotor is suitable. The machine is shown in Fig. 44.

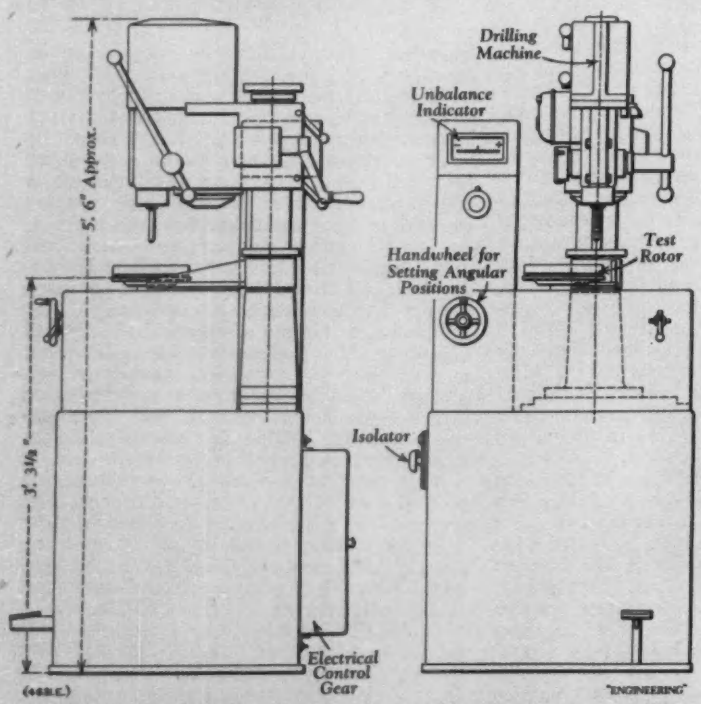

Fig. 44 The vertical dynamic balancing machine incorporates a drilling head and automatic positioning of the test rotor under the drill for correcting any unbalance. W. and T. Avery Ltd.

The machine consists of a base carrying the balancing unit, which includes the drive gear and supporting system

MARINE, WELDING AND NUCLEAR ENERGY at Olympia

Described in this Issue

HALOGEN LEAK DETECTION — *B.T.H. Co., Ltd.*
DYNAMIC BALANCING — *W. and T. Avery Ltd.*
HEAVY FORGINGS — *Thos. Firth and John Brown Ltd.*
ALUMINIUM IN SHIPBUILDING — *Northern Aluminium Co., Ltd.*
JACKS — *Tangyes Ltd.*
SCALE-FREE HEATING — *Incandescent Heat Co., Ltd.*
CENTRIFUGES — *Sharples Centrifuges Ltd.*
THREE-DIMENSIONAL CONVEYOR — *Metalastik Ltd.*
ARGON ARC WELDING — *Saturn Industrial Gases Ltd.*
WELDING POSITIONERS — *Courtburn Positioners Ltd.*
HANDLING TRUCKS — *Ransomes, Sims and Jefferies Ltd.*
CATHODIC PROTECTION — *Cathodic Corrosion Control Ltd.*
CERAMIC AND HARD-FACING ALLOY SPRAYING — *Metallizing Equipment Co., Ltd.*
POWDER-METALS SINTERING FURNACE — *Sintering and Brazing Furnaces Ltd.*
ULTRASONIC ENGRAVING — *Mullard Ltd.*
ROPES — *British Ropes Ltd.*
METAL SPRAYING PISTOL — *Metallisation Ltd.*
FILING MACHINE — *W. F. Johnson and Co. (London), Ltd.*
COOLING TOWERS — *Film Cooling Towers (1925) Ltd.*
MOTORS AND COMPRESSORS — *Wade Engineering Ltd.*
2 : 1 TURBO-CHARGER — *B.S.A. Co., Ltd.*
MARINE GAS-TURBINE — *Bristol Aero-Engines Ltd.*
430 H.P. GAS-TURBINE — *Ruston and Hornsby Ltd.*
FILTERS — *Vokes Ltd.*
FILTERS AND VALVES — *Zwicky Ltd.*
VALVE LAPPING — *Dewrance and Co., Ltd.*
PUMPS AND PRIMERS — *Hamworthy Engineering Ltd.*
SUBMERSIBLE PUMP — *Harland Engineering Co., Ltd.*
HYGIENIC PUMP — *Mono Pumps Ltd.*
CANNED PUMP — *K.S.B. Manufacturing Ltd.*
MARINE SELF PRIMING PUMPS — *J. H. Carruthers and Co., Ltd.*
RUBBER LINED PUMPS — *British LaBour Pump Co., Ltd.*
HIGH PRESSURE LUBRICATION — *British Manzel Oil Pump Co.*
SIGHT GLASSES — *Richard Klinger Ltd.*
FANS AND CLEANERS — *Keith Blackman Ltd.*
MARINE DIESELS — *A. Kracko Ltd.*
LIGHTWEIGHT MANIPULATOR — *H. M. Hobson Ltd.*

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Attendance is one way to gauge the success of an exhibition, and the figures at the time of going to press indicate that this year's show has drawn considerably more visitors than in 1955. Buyers from over 60 countries have attended—including some from behind the Iron Curtain. Another gauge of success is the number of serious enquiries made at the stands: these too have proved very encouraging according to most exhibitors. It will be particularly interesting to see how the change in date of the 1959 exhibition will affect the numbers of those visiting it.

for the test rotors; an indicating unit; and a drilling head, which has a capacity of 1 in. diameter. The indicating unit contains a wattmeter with a central zero and 50 divisions plus and minus of this point. A sensitivity control switch gives full, half and one-fifth sensitivity.

Vibrations of the supporting system due to unbalance of the test rotor produce an electric current in moving-coil pick-ups, and this current is compared in the wattmeter with a current produced by a phasing generator driven from the main spindle. With the control switch in the "run" position, the phasing generator is adjusted by means of a handwheel until a zero reading is obtained on the wattmeter. The control switch is then placed in the "test" position, and a reading corresponding to the amount of unbalance is indicated. If this indication is negative, the control switch is set to "stop (−)"; if positive, to "stop (+)." Operation of this switch stops the rotor, which is then turned by hand until a locating catch slips into position. The rotor is then in its correct angular position under the drilling spindle. The wattmeter indications are linear, and the instrument can be calibrated by means of a potentiometer, thus enabling a simple calibration chart to be prepared for converting the readings into units of correction, that is, depths of holes of various sizes to be drilled.

The rotor supporting system is normally locked, and is automatically unlocked only when the test rotor is running at its balancing speed. As a safety measure the drilling motor is started by the downward movement of the drilling spindle, and is stopped again when the spindle is returned to its original position.

HEAVY FORGINGS

In presenting their exhibits, Thos. Firth and John Brown Limited, Atlas Works, Sheffield, 4, have selected a range of forgings typical of the products of their heavy-forge department. One of these is a 120 MW steam-turbine rotor shaft for the Staythorpe "B" power station of the Central Electricity Authority. The forging, which is exhibited in a vertical position as shown in the illustration, Fig. 45, is in the rough-machined smooth-bored condition. Its main diameter is 4 ft. 6 in., its overall length 18 ft. 8 in., and its weight 31·5 tons.

The shaft will be finish-machined by the Metropolitan-Vickers Electrical Company, Limited, Manchester, for which firm it has been made, and will be fitted with stainless-steel runner blading. The shaft itself is made of 3 per cent. chromium-molybdenum steel and is designed to run at 3,000 r.p.m. in the double-flow low-pressure casing of one of three 120 MW reheat steam-turbine generators.

Another exhibit is one of eight hollow-forged steam-boiler drums designed by Mitchell Engineering Limited, Peterborough, for the State Electricity Commission of Victoria. The drum is manufactured from carbon steel having an ultimate tensile strength of between 32 and 36 tons per sq. in. It is designed for an internal pressure of 1,550 lb. per sq. in., and will evaporate 235,000 lb. of water per hour. Its length is 33 ft., its outside diameter 6 ft. 2 in., and its weight 50 tons.

ALUMINIUM IN SHIPBUILDING

On the stand of the Northern Aluminium Company. Limited, Banbury, Oxfordshire, prominence is given to applications of aluminium in several engineering fields and in shipbuilding, and the growing use of aluminium in shipbuilding is shown by a ship's permanent awning of Noral "Industrial" pattern corrugated sheet, a trawler hatch cover of welded aluminium construction, and a display of extruded sections and rolled plate developed for marine use.

The trawler hatch cover is shown in the illustration, Fig. 46. Designed to meet the requirements of Lloyd's Register of Shipping, the hatch cover constitutes an equivalent, in aluminium, of a standard type of cover patented by MacGregor and Company (Naval Architects) Limited, for trawler hatches, and was made by Saunders-Roe (Anglesey) Limited. Besides reducing the weight to 380 lb., about half that of a steel cover, it is pointed out that the use of aluminium ensures longer life and lower maintenance costs.

The recent installation of new equipment at the Northern Aluminium Company's Rogerstone Works has made possible the production of wide aluminium-alloy plate for shipbuilding purposes. Although the maximum length of the plate available remains the same as that hitherto supplied, namely, 50 ft., the material is now produced in widths of up to 10 or 12 ft. The advantages which this offers, for example in simplifying the fabrication of aluminium-deckhouse sides, will be considerable.

The wide plate is available in the range of alloys and the thicknesses normally called for in shipbuilding and general engineering. It is made by a fabrication technique involving the precision welding of two pieces of plate of normal width. The properties of the resulting double-width plate, it is emphasised, enable it to be used for many purposes in exactly the same manner as plate rolled as a single piece.

JACKS

The Hydraulic Division of Tangyes Limited, Cornwall Works, Smethwick, Birmingham, are exhibiting several examples from their range of jacks and associated equipment. Among these are the climbing jack used in constructional work in monolithic concrete, and new additions to the range of Hydralite jacks.

New models on show have 35 tons capacity with an 18 in. power lift, and a 100 tons capacity with a 6 in. power lift. In the case of the 35 ton model the design is basically the same as the original range, consideration to choice of materials and adjustments to dimensions being all that was necessary.

The 100 ton model, however, is a new design incorporating an entirely new two-speed hand pump, the high-pressure plunger being placed within the low-pressure plunger to form a compact lightweight design. (Fig. 47.)

The two speeds of the pump, giving low pressure or high pressure, are each selected by a push-button situated on the side of the pump body. When the button is in an outward position the pump is on low-pressure operation and the ram of the jack can be pumped out rapidly until it contacts the load and reaches a pressure to lift 10 tons on the jack. The pressure selection button is then pushed in and the pump operates on high pressure for the jack to raise up to 100 tons.

A hand wheel on the side of the pump operates a sensitive needle release valve which, when opened, allows a controlled descent of the ram under load. There is provision for a pressure gauge to be fitted to the pump. A trip device prevents overrunning of the ram.

The two-speed single-acting pump which is incorporated in the new design 100 ton capacity Hydralite jack is also available as an independent unit. When used with the jack, "Hydralite" or similar hydraulic oil is recommended; on no account should water be used. The pump itself, however, is suitable for water or oil.

The pump unit is a convenient simple rectangular form which can be bolted to any flat surface. The high-pressure plunger works inside the low-pressure plunger resulting in a very compact unit. This plunger sub-assembly is very easily removed and when it is desired to change the high-pressure capacity of the unit, the plunger assembly is replaced by one having a high-pressure plunger of the required size. High-pressure plungers are available with diameters to cover a range from 1,600 to 10,000 lb. per sq. in. The outside diameter of the low-pressure plunger is a common size and operates at a maximum pressure of 750 lb. per sq. in. It delivers 3·1 cub. in. of liquid per stroke, which is equal to one pint in 11 strokes.

This pump is also supplied in other forms in addition to its use on the 100 ton Hydralite jack. Its registered name is "Hydrapak."

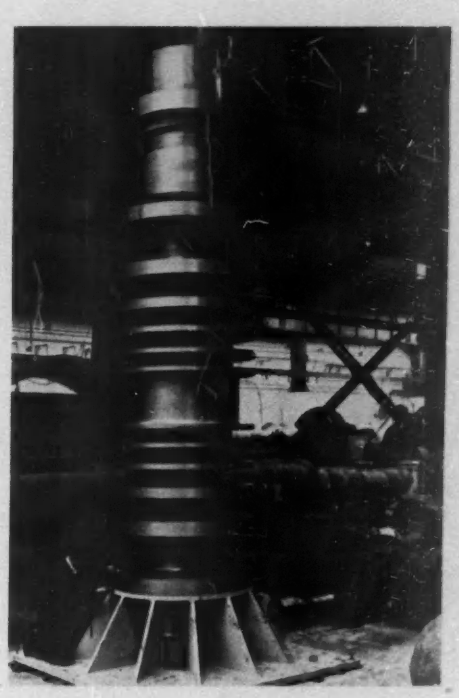


Fig. 45 Forged 120 MW steam-turbine rotor shaft made of 3 per cent. chromium-molybdenum steel. Thos. Firth and John Brown Ltd.

Fig. 46 Welded aluminium trawler hatch cover. Northern Aluminium Company, Ltd.

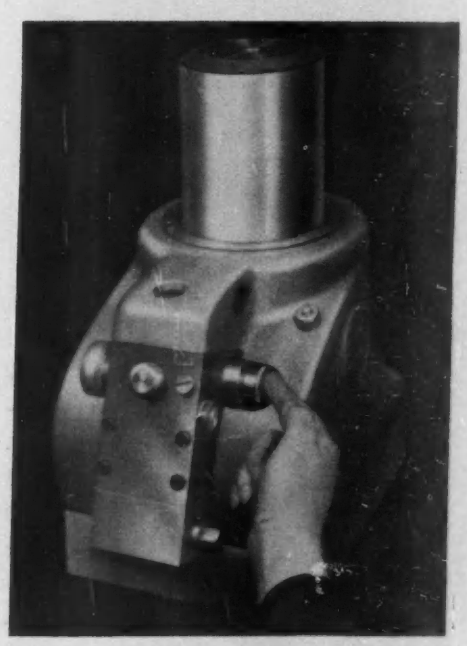


Fig. 47 A push-button gives a choice of high pressure (100 tons) or low pressure (10 tons) loading. Tangyes Ltd.

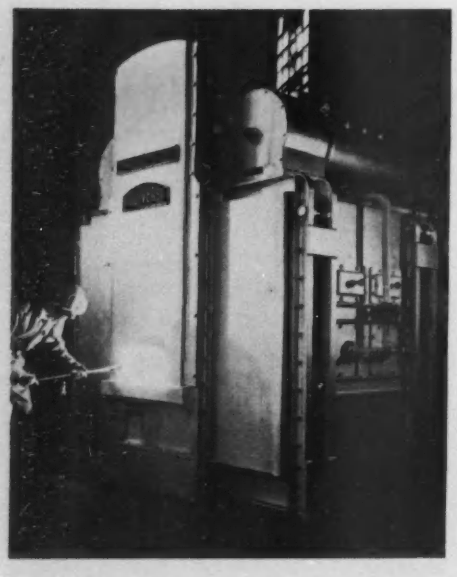


Fig. 48 The regenerator mounted above the gas furnace is a main item in a scale-free heating system. Incandescent Heat Company, Limited.

Fig. 49 A floating drag allows centrifuging to continue despite severe inclinations of the machine. Sharples Centrifuges Ltd.

Fig. 50 (a) left, shows how the Stubbe conveyor can be used for both curved and inclined paths. Fig. 50 (b) right, is a section of the belt which is of rubber-to-metal weld construction. Metalastik Ltd.

Continuing Plant and Equipment

SCALE-FREE HEATING

The " Equiverse " heating system developed by the Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, and displayed on the stand of the Gas Council, is designed to prevent the formation of scale in high-temperature heating processes. The furnace is direct-fired by towns' gas with only partial combustion within to give an atmosphere containing up to 16·5 per cent. carbon monoxide. The potential heat in the high proportion of unburned gas is recovered by pulsators after the addition of air to the flue gases to complete combustion. One model is shown in Fig. 48.

Essentially, the heating cycle is regenerative, with automatically controlled variable flow reversal, by which means high transfer rates are obtained under a slight plenum, preventing the induction of atmospheric air at charging and discharging points. However, while the regenerative principle is used, the specially designed thermal pulsators exceed by many times the thermal rate of exchange obtainable in ordinary regenerative practice because the matrix is entirely metallic, enabling reversing cycles of 30 to 60 seconds to take place. The highly conductive regenerator elements pick up heat rapidly when the flue gases are passing through them, and then release it rapidly to the primary air for combustion when the system reverses.

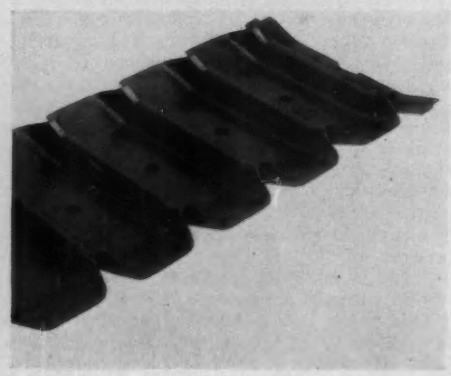
The system can be applied to existing furnaces and is applicable to all processes with temperatures from 750 deg. C. to 1,300 deg. C.

CENTRIFUGES

Equipment for the cleaning and purification of fuel oils is being exhibited by Sharples Centrifuges Limited, Tower Works, Camberley, Surrey. The items include the continuous self-cleaning Nozlejector which is a high-capacity disc-type centrifuge for high viscosity fuel oils. Another is a de-acidifier in which pellets are used to neutralise organic acids of low molecular weight without reacting on any additives that may be present in the oil. The resultant chemicals are insoluble in the oil and can be removed in a second operation by centrifuging. Water-soluble materials are also removed at the same time.

Shown for the first time is a floating drag centrifuge, designed for marine service and illustrated in Fig. 49. This unit has been developed specifically to be immune to the movements that necessarily occur in sea-going vessels while yet giving full oil treatment under all conditions. The centrifuge rotor is flexibly mounted, which allows the centre of rotation to follow the changing centre of mass. This mounting is obtained by suspending the rotor from the drive bearing assembly on a flexible spindle; a loose fitting guide bush permits it to move and to find a position corresponding to its centre of mass. The gyroscopic effect is small and dynamic cushioning is allowed for. Positive lubrication is incorporated from a sight feed lubricator which requires regular filling up.

The unit has been tested on a rocking platform as shown in the illustration, Fig. 49, and has given satisfactory service under conditions of accelerated wear. The assembly can be fitted to



existing 6 P or 18 V machines and will become standard on all new machines of these sizes.

THREE-DIMENSIONAL CONVEYOR

Metalastik Limited, Evington Valley-road, Leicester, a member of the John Bull Group of Companies, have acquired the exclusive manufacturing rights for the United Kingdom of the Stubbe three-dimensional conveyor from Friederich Stubbe Maschinenfabrik, Vlotho/Weser, Westphalia, Germany. The agreement also confers selling rights in a number of countries throughout the world.

Of great versatility, it is pointed out that the conveyor will take coal, minerals of all kinds, stone, powders, sacks, crates or boxes up inclines of 35 deg. or more and in straight or in helical runs. The conveyor, moreover, can turn in curves of less than 10 ft. radius. An installation is shown, together with a section of the belt employed, in the illustrations Figs. 50 (a) and (b). As will be seen at the exhibition, the belt incorporates transverse folds which enable materials to be conveyed up steep inclines without slipping and also permit the negotiation of small-radius curves. Of rubber-to-metal weld construction the belt, which is protected by basic patents, will be made by Metalastik Limited, and negotiations for the manufacture and installation of complete conveyors are in an advanced stage with a firm of constructional engineers.

ARGON ARC WELDING

Saturn Industrial Gases Limited, Gordon-road, Southall, Middlesex, have on show two new models of the Saturn-Hivolt surge injector, argon-arc welding unit. These machines, known as the Mk. II and Mk. III, have been developed from the company's Mk. I model, but incorporate improvements, including a built-in transformer. This enables the complete machine to be mounted in a cabinet on castors; lifting eyes are also fitted, making it completely mobile. Both machines have the same overall dimensions: 36 in. high by 46 in. long by 29 in. wide. These new machines are for welding aluminium and its alloys, and stainless steel. They have a current range of 30 to 600 amps. from a 42 volt open-circuit, alternating current supply, which gives a broad scope for welding and ensures the complete safety of the operator from electric shock. The arc is not nearly as critical as it used to be, and this, coupled with the automatic control of argon and water, reduces operator fatigue and leaves him free to concentrate on welding. Everything is controlled automatically through an on/off switch. The surge injector unit is fitted with an auxiliary device which feeds a higher-voltage spark to strike the initial arc, so avoiding the undesirable " touch-starting " method. As soon as the arc is struck the high-voltage pulse is switched off automatically and the low-voltage surge maintains the arc.

Four new argon arc-welding torches are also included in the Saturn exhibits. A heavy-duty torch with a water-cooled nozzle is rated for use up to 600 amps., while a smaller model has a maximum rating of 300 amps. A new air-cooled torch, with a ceramic nozzle, is suitable for a maximum amperage of 70, and a water-cooled pencil torch is capable of passing up to 120 amps.

WELDING POSITIONERS

A large display of positioners and work-handling equipment for use when welding are on the stand of Courtburn Positioners, Limited, Goldington Bury, Bedford. Typifying the Courtburn range are a 5 cwt. positioner with variable speed and electronic remote control, and at the other extreme, a complete set of equipment for automatic welding of 20 ton cylindrical vessels. This consists of a column and boom, 20 ton rotators, and an operator's platform. The column and boom support an automatic welding head at heights varying from 4½ in. to 9 ft. from the floor, with a 5 ft. reach from the column. Remote push-button controls enable

the boom to be moved over its full range of travel in one minute. Variations of this design are available as required.

The rotators, consisting of a power-driven and an idler section, have a combined load capacity of 20 tons. Dunlop rubber-tyred rollers are fitted, and the equipment will handle cylindrical work-pieces from 24 in. to 15 ft. in diameter. A range of speeds from 4 in. to 80 in. per minute is provided, which covers most automatic and manual welding processes, but other 20 to 1 ranges can be supplied if required. Several settings are provided for the roller brackets, in order to give safe working angles for all work-pieces, and an easy means of adjustment is incorporated. A simple toggle action raises the roller bracket assembly off the frame, the weight is transferred to four small rollers, and the roller bracket can be pushed easily, with one hand, to its new position. When the toggle is released, the roller bracket rests on the main frame again, to support the full working load safely.

The operator's mobile platform accommodates a welder and all his working equipment over varying diameters of cylindrical vessel, and can be used either for manual welding or while controlling an automatic head. The model chosen for exhibition can be raised and lowered hydraulically from 8 ft. 9 in. to 15 ft. 7 in.; other height ranges are also available.

HANDLING TRUCKS

Items of handling equipment are on display on the stand of Ransomes, Sims and Jefferies, Orwell Works, Ipswich, including the Diesel-engined ITW tractor (the industrial version of the MG.6 agricultural and horticultural tractor). It is a lightweight machine with four-wheel drive. Alongside it is a T4 electric tractor with a towing capacity of 10 tons gross.

Among the fork and lifting trucks is the new FL.4500, recently introduced. This has a maximum load capacity of 4,500 lb. The standard lengths of the forks are 3 ft., 3 ft. 6 in., and 4 ft., but these may be varied to suit the customer's requirements. There is also a special high free-lift version available. The object of the high free-lift feature is to enable a unit load to be stacked to a lift height of half the normal full lift in places where the headroom is considerably reduced. It is therefore used in ordinary stacking to full lift height, but also permits stacking in such situations as closed railway wagons where the headroom will not allow the mast height to increase when the load is being raised. Hydraulic foot-operated brakes with internal expanding shoes and independent drums are fitted to the driving wheels and an independent hand-operated brake works the same shoes mechanically. The truck is shown in action in Fig. 51.

CATHODIC PROTECTION

Cathodic protection was first applied on a large scale in the late 1930's to prevent corrosion of buried pipes, and the process was subsequently applied to protect numerous metal structures from attack by sea or brackish water.

Cathodic Corrosion Control Limited, Duncan House, Dolphin-square, London, S.W.1, are showing examples of their new lead-alloy anodes, known as "CX 3," which operate with high efficiency from 2 amperes per sq. ft. to 30 amperes per sq. ft. and at a maximum efficiency of between 5 and 15 amperes per sq. ft. It is emphasised that the anodes are easily fabricated and that their mechanical toughness is high, compared with other materials such as graphite and silicon iron. Their rate of consumption in service is claimed to be exceptionally low owing to the formation of a complex lead-peroxide film which is electrically conducting and causes the anode reaction to take place on its outer surface. Hence, following an initial consumption of the alloy, the dissolution of the anode metal is greatly reduced. Examples are shown in Fig. 52.

The anodes are available in three forms, namely as castings and as extruded cylindrical "lines" and "ribbons." Three standard sizes of castings, complete with threaded inserts of tinned steel have been designed. The sizes are 1½ lb., 5 lb., and 30 lb., and the two smaller anodes are arranged for mounting on insulated supports either singly or in pairs as is shown in the illustration. Cast anodes are used for such purposes as salt-water pipelines and storage tanks, sea-water coolers and heat exchangers, and ships' ballast compartments. Ribbon anodes have been developed for marine applications, particularly ships' hulls, and extruded line anodes are utilised to protect sheet steel piling, offshore drilling rigs, jetties and piers, and laid-up shipping. The minimum life of anodes is of the order of five years.

CERAMIC AND HARD-FACING ALLOY SPRAYING

The firm's new ThermoSpray process and equipment is demonstrated for the first time on the stand of the Metallizing Equipment Company, Limited, Chobham, Woking, Surrey. The pistol used is shown in action in Fig. 53. It is employed for depositing high melting-point ceramic materials, such as alumina and zirconia, and a comprehensive range of hard-facing alloys, all in powder form, at high spraying speeds, on to prepared metal surfaces.

No supply of compressed air is required for the operation of the spraying pistol and only two light-weight hoses are attached to the rear of the instrument. Oxygen and either acetylene or hydrogen are used, depending on the work and the powder to be sprayed. The powder reservoir is fitted above the pistol, as shown in the illustration, and a syphon-jet arrangement at the gun nozzle regulates and accelerates the powder being sprayed. A small electrically-operated vibrator, which is attached to the instrument below the nozzle, is supplied for use when spraying ceramic materials to ensure a smooth flow of the lighter-weight materials.

Coatings of alumina applied by the process are stated to have a hardness of 9 on the Mohs scale and to possess excellent resistance to many types of abrasion. The melting point is 3,700 deg. F. (2,040 deg. C.). A zirconia coating, while softer than alumina, has a greater thermal gradient and may be preferred as a heat barrier. The particle hardness is 8 on the Mohs scale, and the melting point 4,000 deg. F. (2,540 deg. C.).

The hard-facing alloy deposits, of the nickel-chromonium-boron type, range from a readily machineable coating to an extremely hard-wearing deposit. Straight chromium-type stainless steels, nickel-chromium alloys, and an aluminium-iron-bronze may also be sprayed by the new process.

POWDER-METALS SINTERING FURNACE

Among other equipment, Sintering and Brazing Furnaces Limited, 272-3 Terminal House, Grosvenor-gardens, London, S.W.1, are showing the 51 kVA "humpback" conveyor furnace for the sintering of powder-metals, seen in Fig. 54. This consists of three main zones, a de-waxing oven for the removal of organic materials contained in the powder-metal compacts, a sintering-furnace zone, and a cooling-chamber zone. In Fig. 54, the entry end of the furnace is on the left. The work is taken through the furnace on a conveyor mesh belt made of special nickel-chromium heat-resisting steel and travelling at a speed of from 1 in. to 7 in. per minute. The belt is driven by means of a variable-speed motorised unit. The size of the orifice at the entry end is 12·5 in. wide by 4 in. high. The heating zones are fitted with low-voltage oil-cooled transformer-controlled heating elements, and fully-automatic temperature controllers are provided.

The cooling-chamber zone is water-jacketed and is fitted with magnetically-operated valves to control the water temperature in accordance with the nature of the work in hand. Variable thermostats are provided. All temperatures in the various zones are indicated and recorded by instruments shown on the cabinet on the left of

Fig. 51 The FL. 4500 battery-operated fork truck is also available in a high free-lift version. Ransomes, Sims and Jefferies Ltd.

Fig. 52 Cast 1½ lb. "CX 3" lead-alloy anode for the cathodic protection of structures, shown on the right with its tinned-steel threaded insert. On the left two cast anodes are seen mounted on an insulated support. Cathodic Corrosion Control Ltd.

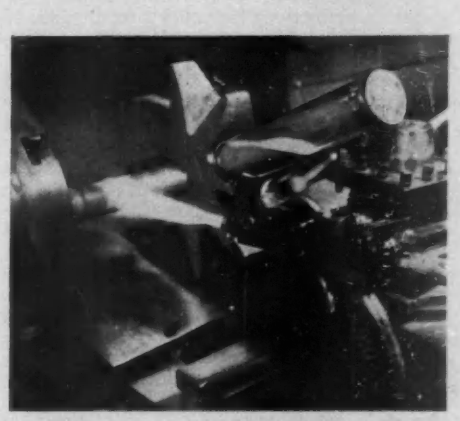


Fig. 53 ThermoSpray pistol, by means of which abrasion-resisting ceramic and hard-facing alloys, in powder form, are gravity fed from a canister, above the instrument, into a stream of oxy-hydrogen or oxy-acetylene. Here they are melted and propelled on to the surface to be covered. Metallizing Equipment Co., Ltd.

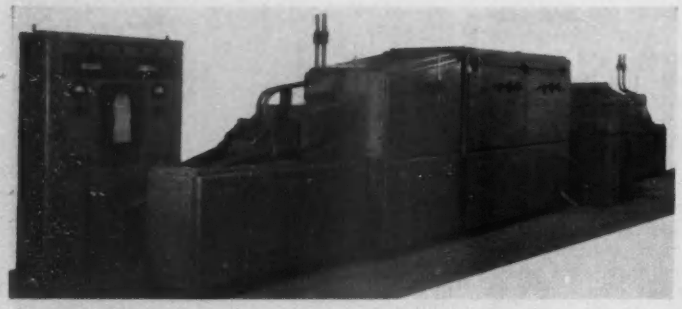


Fig. 54 Conveyor-type humpback electric furnace for sintering powder-metals, consisting of de-waxing, sintering and cooling zones. Throughout the working chamber the atmosphere is controlled, and temperatures of up to 1,150 deg. C. are obtainable. Sintering and Brazing Furnaces Ltd.

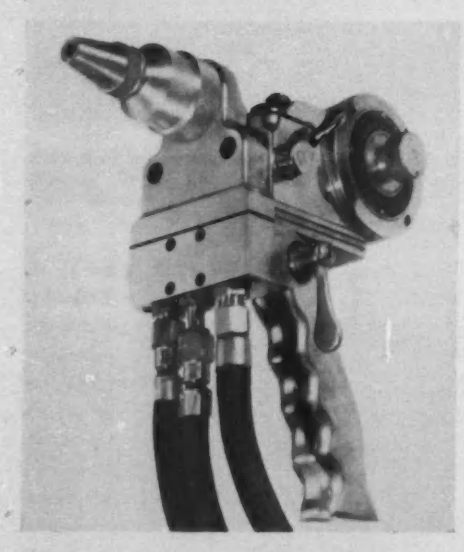


Fig. 55 Metal-spraying pistol, fitted with a fully-magnetic frictionless governor speed control, which deals with metal or alloy wires from 2 mm. to $\frac{1}{16}$ in. in diameter. The gas mixtures used are oxy-propane or oxy-acetylene. Metallisation Ltd.

the main apparatus. Temperatures of up to 1,150 deg. C. are obtainable in the sintering furnace and, throughout, the work passing through the installation is protected from oxidation by a controlled atmosphere; in this connection, the consumption of hydrogen, it is stated, is 85 cub. ft. per hour.

ULTRASONIC ENGRAVING

An ultrasonic engraving tool is being exhibited by Mullard Limited. It is equally suitable for engraving surfaces or for drilling small holes of any shape in hard brittle materials such as glass, ceramics, tungsten carbide and precious stones. For machining operations it may either be used as a hand drill or mounted on a drill stand. For engraving uses it can be mounted in a standard pantograph machine.

The L.274 uses a water-cooled magnetostriction transducer operating at a frequency of approximately 27 kc/s. Transducer vibration is transmitted to the cutting tool by means of a resonant step-up velocity transformer. For the majority of uses the cutting tool is a soft steel tip, identical in shape and size to the hole or pattern that is required, but for fine engraving a diamond-tipped or diamond-loaded tool is used. The cutting tool screws into the end of the velocity transformer and can be changed readily.

Power for the tool is supplied by the Mullard ultrasonic generator type L.275. This has an output of 30 watts and incorporates a feed-back system to maintain the output frequency at the correct value without manual tuning. The size of cut that can be made with the engraving tool varies from 0·005 in. to 0·25 in. maximum lateral dimension. The maximum depth of cut is 0·375 in. According to the particular application, the abrasive will be silicon carbide, boron carbide, or diamond. Normal tap pressure is sufficient for the cooling water, which circulates at the rate of 1 litre per minute. The tool weighs 0·5 lb.

ROPES

Varied materials are employed to make the ropes and cords on the stand of Messrs. British Ropes Limited, Doncaster; steel, P.V.C. and nylon are either alone or in combination. One of the difficulties of steel wire ropes has been corrosion and a protective technique is demonstrated; this is to sheath the ropes or cords with a layer of plastics which completely seals the rope off from outside effects. Another type of rope has a solid plastics core instead of the conventional fibre core. This gives improved resistance to fatigue and so increases the useful life of the rope. The employment of P.V.C. or nylon depends on the end use for which the rope is to be put. Nylon sheathing resists abrasion, kinking and fatigue. P.V.C. cords are chemically stable and offer resistance to attack from both acids and alkalis.

Other advantages include the simplicity of joining cores, by hot butt or scarf welding. As a special feature a steel reinforcing strand at the centre can be included to limit the elongation to specified ranges. On the stand is also a portion of a flattened strand rope, 13½ in. in circumference, believed to be the largest ever made.

METAL SPRAYING PISTOL

What the makers, Metallisation Limited, Barclays Bank Chambers, Dudley, Worcestershire, claim to be an entirely new metal-spraying pistol is being demonstrated on their stand. Shown in Fig. 55, it is known as the Mark 33 and succeeds the firm's Mark 16 pistol. A new feature is the fully-magnetic governor speed control which is frictionless and gives a speed range of 2½ in. to 18 ft. per minute with maximum power at all speeds. It is claimed that any metals or alloys capable of being drawn into wire form, from 2 mm. to $\frac{1}{16}$ in. in diameter, may be sprayed and no gear changes are necessary, the self-aligning dual-powered feed rollers taking all sizes of wire. To change from one wire diameter to another it is only necessary to change the wire nozzle. The latter is a single-piece fitting and is furnished with long-life inserts.

We are informed that a new gas-feed system, without gas plates, ensures perfectly homogeneous gas-oxygen mixtures. The mixtures used are oxy-propane or oxy-acetylene and, in Fig. 55, the oxygen enters the pistol by the left-hand tube, the propane or acetylene by the middle tube and the compressed air, which operates the wire-feeding mechanism and atomises the molten metal, by the right-hand tube.

FILING MACHINE

W. F. Johnson and Company (London), Limited, are showing a range of bolts, nuts and small tools. One of the machines exhibited is the Elmas-Discut, a filing machine designed for use with softer materials with the particular intention of avoiding clogging. The cutting disc is made from a stamping and has a 10 in. diameter. It can be replaced easily and cheaply. Four models are made for voltages ranging from 110 to 440 volts d.c. or a.c., single-phase or three-phase, in either bench or cabinet forms. The speed of the standard machine is 237 r.p.m. with an overall weight on the bench model of 90 lb. The power is supplied from a ½ h.p. motor; the ground area required is 11 in. by 21 in., and the work rest table is 4 in. by 11 in. The tool was particularly designed, as mentioned earlier, for use with the softer materials, such as thermoplastics, nylon, p.v.c., or polythene, together with such other materials as bakelite, urea compounds and alloys like Mazak and white metals.

Continuing Plant and Equipment

COOLING TOWERS

Exhibits on the stand of Film Cooling Towers (1925) Limited, Lionel-road, Kew Bridge, Brentford, Middlesex, include a laminated hardwood impeller, one of the specially designed gearboxes and a shaft with couplings used in the fan drive equipment. The application of these components is described photographically on the stand.

Photographs are also shown of various concrete shell natural draught hyperbolic type cooling towers. A large number of towers of this type have been designed and constructed both in this country and overseas. Among them may be mentioned the largest towers yet commissioned for the Central Electricity Authority, namely, the three 4½ million gallons-per-hour towers constructed at Hams Hall power station.

The main exhibit on the stand is a scale working model of an induced draught cooling tower. This model has a transparent cladding showing the internal working of the "All Film Flow" packing. The design is similar to the packaged type coolers supplied to the Atomic Energy Commission for their Calder Hall and Chapelcross generating stations; sixteen of these cooling towers are to be employed at each of these stations.

The grid packing lends itself to compact designs with low pumping heads and minimum fan power. These factors together with the very close approaches to the wet bulb temperature, are due to the extensive research carried out initially by the Imperial Chemical Industries Limited.

The system has almost completely superseded the older splash bar packing in applications where low re-cooled temperatures are required. This is particularly true where the plant has a high use factor and the saving in pump and fan power quickly offsets any additional initial cost the machining of the "Film" packing may involve.

Cooling towers have been supplied for capacities as low as 140 gallons per hour and up to 3,000,000 gallons per hour both at home and overseas.

MOTORS AND COMPRESSORS

Wade Engineering Limited, Crowhurst-road, Brighton, Sussex, are exibiting a range of Root's type superchargers with stock models going up to 550 cub. ft. of free air per minute against back pressures of 10 lb. per sq. in. In addition there is a portable respirator pump designed to replace the iron lung for patients suffering from poliomyelitis, which was exhibited at the previous Exhibition.

Examples of products under development include a small air motor working on the Root's principle which has been primarily designed for aircraft applications and in particular for use with actuators. It is intended to operate at low air pressures (between 3 and 10 lb. per sq. in.), and the unit, developing ½ h.p, measures only 4½ in. by 3½ in. by 3 in. The direction of rotation can be reversed by a single change-over lever. The advantages claimed for the air motor are that stopping and starting are instantaneous and rotational speeds are high. It can also be used in conditions where high ambient temperatures are encountered.

Another item shown which is also still under development is a variable compressor mechanically driven and developed from the Root's type of two lobe unit. A single stage can give pressure ratios up to 3 to 1 and variable compression is obtained by a lever which alters the timing of the air release. Such an arrangement enables a constant speed driving motor to be used with automatic control of the delivery by varying the compression.

Also on the stand is a turbo-charger designed

for use in engines of approximately 150 h.p. which has positive displacement and on which maximum speeds of all parts are limited to 200 ft. per second. The development is said to have reached the stage where component efficiencies can be obtained that are equal to those found on the centrifugal counterpart.

2 : 1 TURBO-CHARGER

Exhibited by the Birmingham Small Arms Company, Limited, Birmingham, 11, is the turbo-charger they have developed with a normal 2 : 1 compression ratio. Two sizes are made, the smaller for engines in the 100 to 200 h.p. class, and the larger for engines up to 400 h.p. The former is shown in the illustration, Fig. 56. Extensive trials have been carried out on the unit, both in the laboratory and in service on a bus engine operating in a hilly district.

The charger has a gross weight of 30 lb. and a normal running speed of 59,000 r.p.m. The rotating assembly, complete with the two ball races, weighs only 2½ lb. so that the speed of response is extremely rapid. Overall dimensions are approximately 8¾ in. diam. by 8 in. long. Aluminium and light alloy castings have been used wherever possible and a heat shield is incorporated behind the turbine rotor. A full description of the charger will be given in a subsequent article.

MARINE GAS-TURBINE

The Marine Proteus, the marine version of the Bristol Proteus turbo-prop engine (power unit for the Britannia airliner), is being shown on the stand of Bristol Aero-Engines Limited, Filton, Bristol. The engine has been developed in collaboration with the Admiralty. It is shown in Fig. 57.

Basically similar to the Proteus aero-engine—although it has been de-rated—the marine version provides a compact and light unit for its power. Measuring 42 in. wide and 112 in. long, it weighs only 2,900 lb. It develops 3,500 s.h.p. Having a "free power turbine"—that is, a turbine driving the propeller which rotates independently of the compressor rotor—the engine delivers extremely high power at low or medium propeller speeds, giving rapid acceleration to the vessel. Control, apart from starting and stopping, is by a single lever, and there is no necessity for warming up the engine as there is with piston-engined power units. The engine has already completed well over 1,000 hours' running under simulated sea-going conditions.

In one test of 225 hours on the marine engine, salt water was sprayed into the intake at twice the maximum rate ever recorded during sea trials. Following this test, it was proved that even if the engine's compressor blades become so encrusted with salt that there is a slight fall-off in performance, they can be washed clean and normal power restored within five minutes. This is done by running the compressor at idling speed while distilled water is injected into the air intake from an annular "rose" attached to it for this purpose. It has been shown that the salt has no permanent effect either on performance or on the life of the components. The only important difference from the aero-engine, apart from the reduction gear, is the incorporation of corrosion-resistant materials wherever necessary.

430 H.P. GAS-TURBINE

The Mark TE gas-turbine exhibited by Ruston and Hornsby Limited, Lincoln, is a smaller machine than their TA model, but is also designed for general use. The one shown at the exhibition is intended as a marine auxiliary. Its rating is 300 kW as against 900 kW for the TA. It is shown in Fig. 58.

The machine is a single-shaft type, running on the open cycle. A single-stage compressor is used with a three-stage axial-flow turbine developing 430 b.h.p. (at 80 deg. F.), continuous rating. The rotor speed of 19,250 r.p.m. is stepped down in a gearbox to either 1,200 r.p.m. or 1,500 r.p.m. as required. The gearbox is rigidly attached to the forward end of the engine and the governor and accessory drives are taken from it. The combustion chamber is mounted at right angles to the engine axis, just off the vertical position. An air cooling system supplied from the compressor prevents damage during sudden starts or stops. Class A distillate oil or natural gas can be used as fuels. A detailed description of the engine was given on page 315 (issue of September 6).

FILTERS

Vokes Limited, Guildford, Surrey, are showing a large selection of filters and screens both for air and liquids. Examples of all their standard range of air, lubricating oil and fuel filters are shown, both for ordinary conditions and for high humidity, high temperature applications. There are also filters designed for pharmaceutical and bacteriological laboratories. Several items are being shown for the first time and one of these is the Auto-Roll, an automatic screen-type air filter for air conditioning and ventilator systems. For this the filtering medium is disposed between two rollers so that the replacement of dirty cloth is effected by a few turns of the lower roller. In another variant, a rotating screen of wire mesh panels operates in conjunction with an oil bath which offers a reasonably high efficiency under heavy dust concentrations and does not require servicing.

For lubricating oil there is a filter utilising a new medium, designated VAF 66, of which one salient feature is its great inherent strength rendering a wire mesh support unnecessary. It is also claimed that these units offer a lower resistance and, therefore, permit a greater flow of the liquid. A warning indicator has also been developed for fluid filters to give ample warning of the need for replacing the element before by-passing or excessive pressure drop occurs.

FILTERS AND VALVES

Filters, valves, pumps and lubricators make up the exhibits shown by Zwicky Limited, of Slough, Bucks. Examples of their standard ranges are included and new items are the pressure control valve and self-cleaning filter. The pressure control valve shown in the illustration, Fig. 59, is made in two forms, one of which is designed to control the pressure down-stream, as is required to regulate the fuel oil supply to burners, and the other to regulate the pressure up-stream, forming what is essentially a safety valve for use in gallery systems. Both are made in sizes ranging from ¼ in. bore to 2 in. and have flows up to 3,000 gallons per hour. The test pressure is 150 lb. per sq. in., and the standard working temperature is 100 deg. C. Standard springs, as fitted, will give down-stream pressures ranging from 3 to 10 lb. per sq. in., or up-stream pressures from 15 to 35 lb. per sq. in.

Self-cleaning filters known as "Zwikleen" are made in three sizes, with 1 in., ¾ in., and ½ in. British standard pipe threads. They are designed for handling oils ranging from 50 sec. Redwood No. 1 to 500 sec. The filtration element is based on perforated steel discs separated by spacers, the depth of which may be varied according to the particular requirements. A series of scraper blades is mounted on the shaft of the external handle so that one turn of the latter removes the whole of the accumulated dirt, which falls into the sump at the bottom of the filter casing. The direction of flow is from outside to the centre of the element; the maximum working pressure is given as 50 lb. per sq. in., but all filters are tested up to 100 lb. per sq. in. A larger range covers pipe bores from 1¼ in. to 2 in.

VALVE LAPPING

Mountings and pipeline valves for power stations, industrial, and marine installations form part of the exhibits on the stand of Dewrance and Company, Limited, Great Dover-street, London, S.E.1. Several are being introduced at the Exhibition for the first time and these include small bore steel valves for pressures up to 600 lb. per sq. in. and temperatures up to 875 deg. F., of which the special feature is a fabricated body eliminating heavy cover flanges and bolting. The internal components can be withdrawn after the removal of a small screwed plug. There are also Monoway valves for pressures up to 3,000 lb. per sq. in. and temperatures up to 1,065 deg. F. which are suitable for auxiliary steam, oil or water services. These have a parallel slide disc, with the fluid pressure acting on the top of the valve to assist in forming a positive seal. The bellows-sealed stop valves form another part of the exhibit and there are also a group known as "Stufline" valves for control of thick liquids or wet grain.

To assist in the maintenance of valves, the Dewrance-Croft lapping machine has been introduced. This is shown in Fig. 60. By its aid, the valve seal face can be ground *in situ* in order to avoid having to cut the valve out of the line. The machine will lap in one operation both seat faces of parallel slide valves of any make. It is made in several sizes to cover a range of valve sizes from ¾ in. up to 14 in. A self-contained machine is available for small bore valves which requires no outside source of power. Other machines are power operated by an electric motor and require a compressed air supply for pressurising the lapping head.

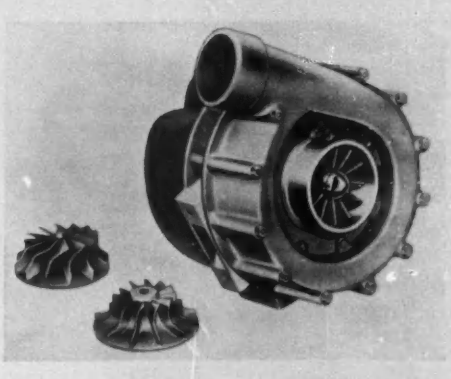


Fig. 56 Weighing 30 lb., the turbo-charger gives a 2 : 1 pressure ratio. B.S.A. Co., Ltd.

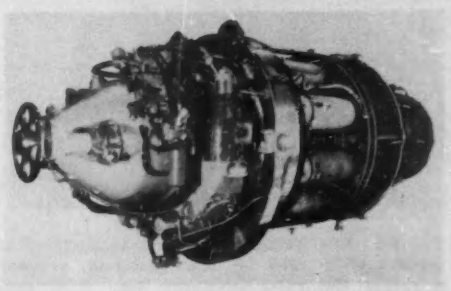


Fig. 57 The Proteus turbo-prop engine has been developed for marine use. Bristol Aero-Engines Ltd.

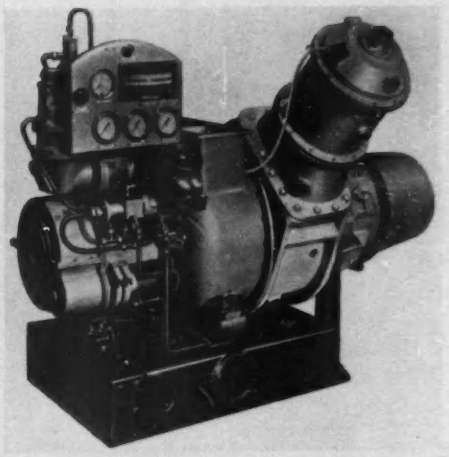


Fig. 58 The TE gas-turbine for general industrial use is rated at 300 kW. Ruston and Hornsby Ltd.

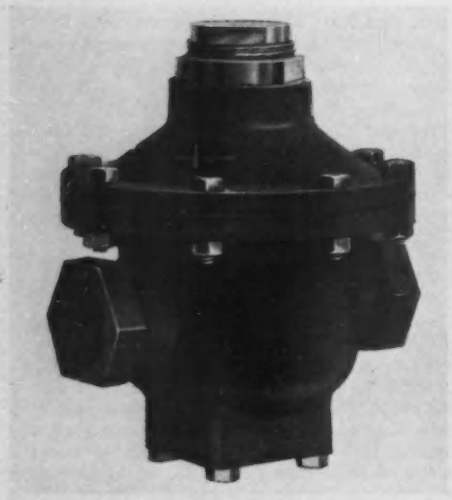


Fig. 59 Pressure control valves for both up-stream and down-stream regulation. Zwicky Ltd.

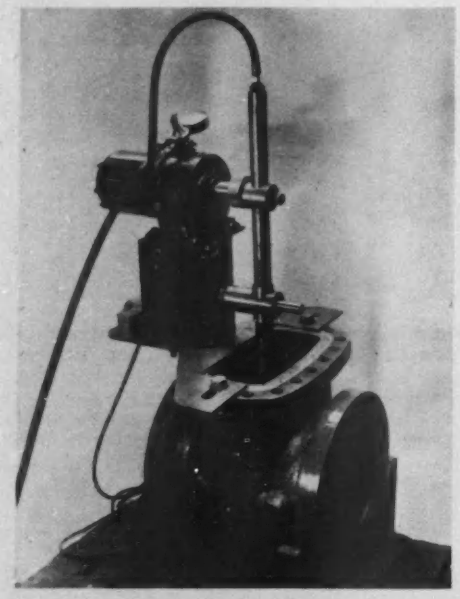


Fig. 60 This machine will lap both faces of a parallel slide valve in one operation, without removing the valve from the line. Dewrance and Co., Ltd.

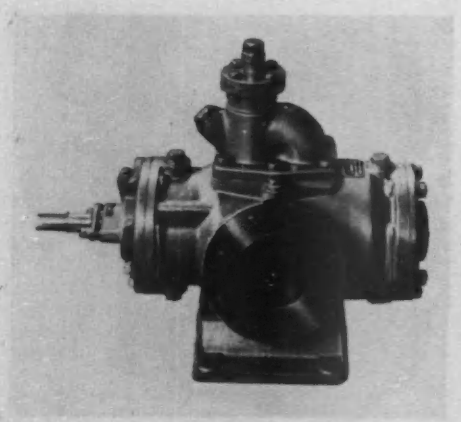


Fig. 61 Screw pump for liquids having some degree of self-lubrication. Hamworthy Engineering Ltd.

Continuing Plant and Equipment

PUMPS AND PRIMERS

A series of screw pumps not previously exhibited in Britain is on display at the stand of Hamworthy Engineering Limited, Poole, Dorset. Sizes of pumps are available up to a maximum capacity of 100,000 gallons per hour, to deal with a diversity of fluids of varying viscosity and pressure, but particularly those which have reasonable lubricating properties. One is shown in the illustration Fig. 61. The operation is that completely enclosed cavities between the threads of the screws move forward in an axial direction without creating turbulence. The screws are carried on bearings which are lubricated by the fluid being pumped, at its full pressure. A spring-loaded mushroom head valve is fitted to operate as a relief valve and is normally set to operate at 10 per cent. above working pressure. Different forms of mountings are available for the pump. Another new development on the stand is the AVP 16 centrifugal pump typical of a range of large capacities; the biggest member is capable of handling 3,350 tons per hour at a head of 30 ft. For priming this and other pumps a liquid ring primer capable of handling large quantities of air for a small consumption of power has been developed and is being exhibited. It operates in conjunction with an air separating chamber and a fluid-operated valve mechanism. An example of the radial-vane type of pump is the Beaver, also shown for the first time in this country. These are single-stage pumps designed for simplicity and economy.

SUBMERSIBLE PUMP

The main features of the stand of the Harland Engineering Company, Limited, Alloa, Scotland, are examples of their ranges of submersible pumps, in particular the Ulectriglide pump set. The standard range, which includes the two types, the Spyrobowl for smaller bore diameters and the Spiroglide, where larger bores permit higher heads per stage, covers duties up to 950 gallons per minute and heads up to 1,000 ft. with motors up to 130 h.p. Squirrel-cage motors used are of the completely wet-type designed for the restricted diameters.

HYGIENIC PUMP

The products of Mono Pumps Limited and Menrow Limited are being shown on a combined stand under the title of the Mono Group, 1 Sekforde-street, London, E.1. Exhibits are divided into marine, industrial and powder pumps, and oil-conditioning plant, industrial filters and oil fuel pumps. Under the marine division is a complete Mono pressure system operating under shipboard conditions. Automatic control of the system is effected from a multi-motor control panel. The new hygienic pump is shown by the industrial pump division. It is designated the Mono Kwikleen K63 type, and is shown in the illustration, Fig. 62. The pump is available on the stand to demonstrate the quick and easy method of dismantling for sterilisation, stripping being carried out by two simple operations merely with the aid of a combined screwdriver and tommy bar. All internal surfaces of the pump are polished stainless steel and the stator is of non-contaminating composition. The pump is suitable for handling milk and other fluid edible products. It is self-priming up to 25 ft. and can be used for vacuum extraction duties. The makers claim that the consistent rate of discharge makes it ideal for high-temperature short-time processing.

A range of these new Mono Kwikleen pumps is expected to be produced. The pump now available has a capacity up to 3,000 gallons per hour with a maximum pressure of 30 lb. per sq. in.

CANNED PUMP

Among the pumps and equipment on the stand of K.S.B. Export G.m.b.H., whose London representatives are Messrs. K.S.B. Manufacturing Limited, 6 Broad Street-place, London, E.C.2, is an example of an hermetically sealed circular pump, type LUV. This is shown in the illustration, Fig. 63.

The pump is of the type that is suspended vertically in the piping and the motor can be withdrawn from the bottom of the casing without disturbing any other part of the layout. The pump has axial suction and gives radial discharge through branches of different types. A "heat lock" is fabricated from steel sheets between the hot pump end and the cold motor end. The cooling water circulates between these sheets. The motor is a standard wet type, three-phase induction rated at 68 (metric) horse-power, having two poles and running at a speed of 2,950 r.p.m.; the shaft is carried in water-lubricated sleeve bearings at its lower end and a small auxiliary impeller is fitted which supplies cooling water to the bearings and motor windings. On endurance test a steady water temperature of 310 deg. C. was attained with an output pressure of 1,991 lb. per sq. in. rising to 2,418 lb. per sq. in. for short periods. The delivery was 937·5 Imperial gallons per min. The corresponding winding temperature was 30 deg. C.

MARINE SELF-PRIMING PUMPS

The stand of J. H. Carruthers and Company, Limited, displays examples of their reciprocating and centrifugal cargo pumps. One particular newcomer is the Flowmaster vertical model of which both self-priming and standard types are made. One is illustrated in Fig. 64.

The intention of the design was to produce a centrifugal pump which was self-priming, incorporating a means of operation without the necessity for an external air exhauster. The range is manufactured in sizes from 3 in. to 9 in. in diameter of suction bore, with outputs from 10 to 500 tons per hour against operating heads of 30 to 450 ft. They can be supplied as single-stage or two-stage units, and in the latter case, the impellers can be connected to operate in series or parallel so that high pressure or high output can be obtained. The priming tank forms an integral part of the whole pumping assembly. The drive from the motor is taken through a Hardy-Spicer coupling.

The auxiliary vane system on the upper side of the impeller draws water from the reservoir or header tank and throws it into the main pump casing. This creates a vacuum in the main impeller intake, so drawing up the fluid to the suction eye when the main impeller starts to operate and the pump is primed. A reflux control valve in the output branch operates so that, when the pump is priming, the small flow of water is not sufficient to move the valve and is thereby directed back into the header tank. When the pump begins to run full, the reflux valve opens and allows discharge to occur.

RUBBER LINED PUMPS

The range of pumps shown by the British LaBour Pump Company, Limited, Blundell-street, London, N.7, includes several new versions. Types UHL and UPL are fitted with new pump and impeller assemblies while the pump casing itself remains virtually unchanged. Of general interest on this stand are the sectioned models which demonstrate to users the operating principles and the construction of the pumps. A recent development exhibited for the first time is the type USL, designed specifically for the mining industry. It is a self-priming pump for operation in confined spaces and will run satisfactorily for long periods on snore. The separator is mounted at the side in order to keep the overall height as low as possible. The pumps are fitted with a P.T.F. seal manufactured by Crane Packing Limited, which completely encloses the shaft. The seal requires no lubrication or external cooling aid and no foot valve is required for use with this pump. It is shown mounted on a skid-type baseplate but can equally be supplied with any other mounting arrangement.

Other models include the SGHL, which has

been developed for vacuum extraction duty, and the U Z, a type that has now been fitted with a rubber lining and a mechanical seal so that it is suitable for handling acids or corrosive chemicals generally, or any other application where metal contact would be unsuitable. The impeller and shaft are completely enclosed in a Vulcoferran coating which is subsequently machined to the exact size required. As the cover is extended up the shaft (and is also machined to give a close running fit), no part at all of the metal is exposed to the fluid being handled.

HIGH-PRESSURE LUBRICATION

High-pressure mechanical lubricators are being exhibited by British Manzel Oil Pump Company, Durran Hill-road, Carlisle. Single- or multi-unit models are shown with operating pressures up to 6,000 lb. per sq. in. In the multi-unit model, not only can the supply of oil be varied, but each plunger can be individually adjusted to suit the lubrication point that it serves.

One feature of these pumps is that the feed pipe at the top is enclosed in a transparent plastics shield so that the flow of oil is always visible; a sight glass in the tank gives the level of the oil present. The plastics cover is not subjected to the working pressure of the pump, but is actually under a slight vacuum, which also has the effect of preventing misting, thereby ensuring that the flow is always visible. The suction of the plunger draws the oil from the drip pipe in the sight glass and into the inlet port of the cylinder and the return stroke forces oil up the delivery pipe to the point to be lubricated. The drive can be taken from either end of the complete lubricator, and sizes with total capacities up to 20 pints with as many as 16 feeds at 500 lb. per sq. in. are available.

SIGHT GLASSES

Richard Klinger Limited, Klingerit Works, Sidcup, Kent, show the extension to their range of piston valves that has been made since the last Engineering Exhibition. The remote control types have now been increased by the addition of hydraulic operation and a particular exhibit is a working unit of four different sizes of piston valves, complete with the hydraulic operating pump and the operating panel and indicator system.

They are also showing examples of their latest design of level gauge which is suitable for boiler pressures up to 2,000 lb. per sq. in. In this model, the RTA, the two flat plate glasses have parallel surfaces but are offset so that the line of sight from the gauge is not perpendicular to them. The line of sight for an observer is, therefore, diverted to a greater extent when passing through vapour than when passing through water, and the two emerging lines strike a contrasting surface in the illuminator fixed at the back of the gauge. These surfaces can either be red and green opalescent glass or a white glass screen and darkness. This level should always be viewed from immediately in front of it and will require a mirror or periscope attachment if it is to be viewed from below.

FANS AND CLEANERS

Keith Blackman Limited, Millmead-road, London, N.17, are exhibiting a wide range of their products. These include fans from their standard series together with other items such as the Keno hydro rotor filter. The latter is being shown at this Exhibition for the first time. It is a wet washer of low resistance suitable for trapping finely divided dust from the air stream as, for example, from paint booths. It differs from the Mark I model in that the casing is bifurcated and has a square instead of circular cross-section. Also the water elevating helix is directly driven by a motor mounted in the casing.

Another dust collector is the model PD/KB design multi-tubular type. It is used for the removal of flue ash from the flue gas of large power stations where mechanical stokers are fitted or pulverised fuel is burnt and for other similar situations.

The new Tornado four-way welding fume exhaust unit is another item that is on display for the first time. The four exhaust hoses can extract fumes from welding positions which may be as much as 60 ft. apart. The exhaust unit is self-contained once the connection to the mains has been made, and one of them is shown in action on the stand of Lincoln Electric Company, Limited.

MARINE DIESELS

The medium-speed marine Diesel engines displayed on the stand of A. Kracko Limited, 3/4 Crooked-lane, London, E.C.4, are from the ranges made by Klöckner-Humboldt-Deutz.

Of interest is the fully-automatic load-controlled generating set featuring an air-cooled Deutz Diesel engine of the F1L 612 type. It produces 4 kW and starts running automatically when the load, e.g. a bulb, is switched on, and stops automatically once the last load is switched off. This generating set is placed under a Plexiglass hood, so that the cooling air can be re-circulated and, as a consequence, the engine temperature appreciably increased. At the exhibition, the running temperature was just over 140 deg. F. within the hood.

The A.M. 528 series, of which a 3-cylinder version is exhibited, includes models with 3, 4, 6, and 8 cylinders and outputs ranging from 95 to 620 b.h.p. These engines work on a four-stroke cycle and have direct fuel injection.

Normal working speed ranges from 400 to 750 r.p.m. rendering the engines suitable for marine propulsion and some locomotive and industrial use. The 6 and 8 cylinder are available as direct reversing. They can also be equipped with exhaust driven turbo-chargers if required. The bore and stroke for these engines are 8¼ in. by 11 in., respectively, giving a mean piston speed of about 11,000 ft. per minute.

The quoted fuel consumption on full load is 0·37 lb. per b.h.p. per hr. rising to 0·047 lb. per b.h.p. per hour on half load on the 3-cylinder naturally aspirated model, or to 3·85 lb. for the supercharged version.

Compressed air is used for starting and forced lubrication is employed throughout. The maximum torque is developed in the region of 500 r.p.m.

LIGHTWEIGHT MANIPULATOR

On the stand of H. M. Hobson Limited, Wolverhampton, the Model 7 master-slave manipulator is exhibited. The unit is mechanically operated and is portable. It has a handling capacity of 10 lb. per arm and a weight per arm of 48 lb., complete with channel and roller mounts.

The manipulator comprises basically a pair of horizontal beams to which the tubular arms are attached by universal joints. Bowden cables connect the hands at the master end to those at the slave end. The system of counterbalancing enables the forces required to initiate and maintain uniform movement in the horizontal plane to be less than 2 oz. In the vertical plane 5 oz. are required.

The master ends are equipped with hands that are adjustable for different hand sizes. They are also fitted with a locking grip. At the slave ends general-purpose tongs are supplied as standard equipment and are remotely interchangeable. Aluminium and stainless steel are the main materials used in the construction.

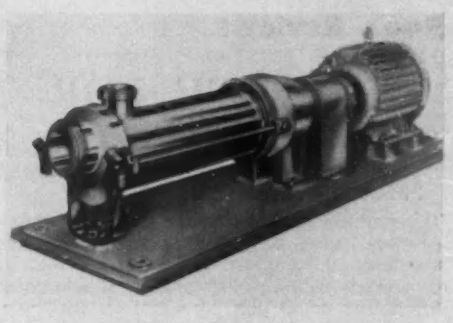


Fig. 62 Hygienic pump for food products, designed for easy sterilisation. Mono Pumps Ltd.

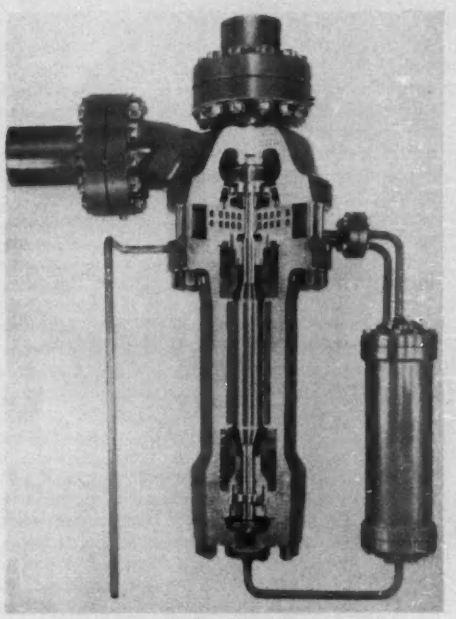


Fig. 63 Hermetically sealed high-pressure pump. K.S.B. Manufacturing Ltd.

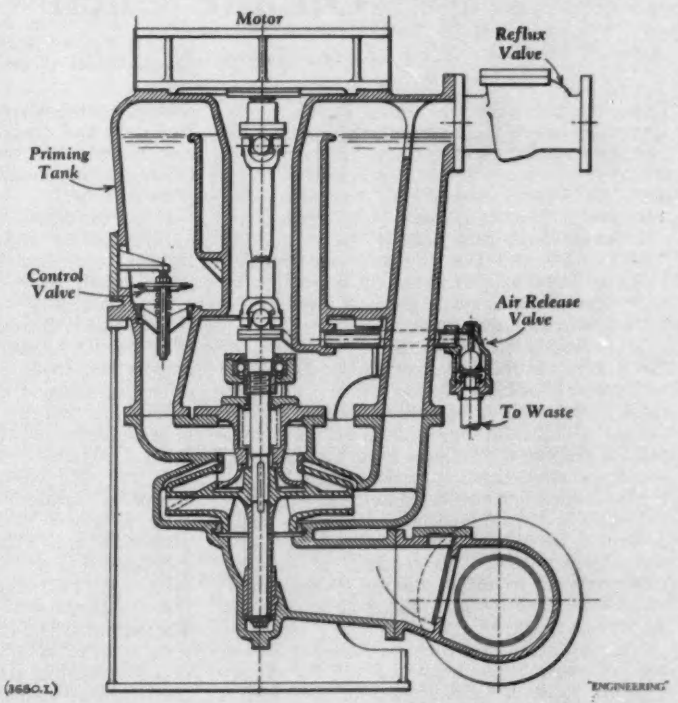


Fig. 64 The Flowmaster range of vertical pumps embodies a self-priming arrangement. J. H. Carruthers and Co., Ltd.

Book Reviews

RECIPE FOR THE NEW POOR

Science and Economic Development. By RICHARD L. MEIER. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (48*s.*)

The problems which face the people of underdeveloped areas in their attempts to raise their standards of living are too often discussed by economists with little knowledge of science or technology or, at best, by social scientists who are overwhelmed by the political and social problems involved in rapid technical change. The author of this book is both an industrial chemist and a social scientist whose work has been largely concerned with the inter-relations between the natural and social sciences.

Fascinating though much of what he writes is, it cannot be said that it is highly digestible; for the wealth of information and speculation which he provides seem to combine the enthusiastic programming of the technocrat (a possible criticism of which he is aware) with the more extravagant extrapolations of the writer of science fiction. Like so many Americans, a planner *manqué*, he might have spent a little more time in organising and pruning some of the great quantity of material on which his book is based.

Following a whole line of writers before him, but with less pessimism, he surveys the future trends in world population, and the demands for resources and possibilities of fulfilling them, and comes up with some original methods of coping with the problems that they are going to pose. Anticipating a world population of three to three-and-a-quarter billions (American nomenclature) by the year 2000 A.D. and a maximum population that the earth could sustain of 50 billions, he examines the techniques of food and energy production and the social organisation that will be needed to make these potentialities into reality. A new concept is produced known as the "minimum adequate standard of living" (M.A.S.L.), based not on a value judgment, but on the physical requirements of a good life, as determined by the body of accumulated scientific knowledge. This turns out to cost 331 dols. per person annually at United States 1950 prices and would need an annual production per worker, to support his family and to provide savings for investment of 30 to 40 per cent., of the present American level. In order to achieve the level of saving required for such an expansion, Dr. Meier advocates for developing countries a controlled distribution of individual incomes so that the M.A.S.L. becomes a virtual wage ceiling. This would encourage the mass production of "utility" goods of low cost and enable all surplus production to be used for investment in the developing economy. Such a policy would help to prevent the political violence which arises when there are great extremes of wealth and poverty as there were in England in the Nineteenth Century and as there are in the Middle East to-day.

Believing that world needs of proteins will exceed the potential supply produced by present methods in the 1960's, of fruit and vegetables in the 1970's, and of carbohydrate foods some time after A.D. 2000, Dr. Meier goes into great detail about the microbiological methods of food production (*algae*) and even of energy. He is perhaps more sceptical of the immediate future of atomic energy than he would have been if he had written the relevant chapter a year or two later; but is undoubtedly correct to emphasise other methods, such as solar heating, which are more suitable for small communities lacking the enormous financial and technical resources required for nuclear plants.

Aware of the prejudices which prevent the adoption of new methods, including those of eating, he devotes some space to the way in which people can be "conditioned" into liking new forms of food. In a book not oversensitive of the dignity of the individual, this advocacy of the more dubious methods of certain advertising agencies has a rather unpleasant flavour.

Perhaps the most interesting and thought-provoking part of this book is that in which the author examines the adjuncts of the modern Western pattern of living and asks for a re-examination of them in the light of the customs, as well as the economic potential, of poorer peoples. With scientific research he is convinced that new and more inexpensive ways can be found of providing for the physiological needs and comforts of millions of people at present feeling deprived because they cannot achieve the prestige associated with, for instance, the glossy kitchens and bathrooms portrayed in Hollywood films.

Anticipating a great growth in the size of cities, as surplus labour leaves the farms and becomes industrialised, Dr. Meier envisages areas of continuous urbanism, extending for hundreds of miles. A city of this size he calls a "megapolis" and he makes a plea for more research into its planning and into the way in which a previously rural population can be introduced into it without too much social dislocation. There is no doubt that his criticism of the usual administrative separation between town and country planning and economic and industrial planning is justified. That he is not obsessed with technological advance alone is illustrated by his surprising suggestion that the bicycle and the handcart are the best and cheapest method of local transport in cities!

It is a pity that Dr. Meier has not separated more clearly those of his ideas which are intended to stimulate us to think out long-term aims and methods afresh and the more practical politics of his approach. In fact, the one aspect of sociology which he almost completely neglects is politics and, in the sense that political sociology is the study of the organisation of administration and policy-making in a country, it is the required study for economic and social change. Without the political power nothing can be done.

In one other sphere he comes to the same conclusion as all those who have previously dealt with this subject—that of population growth. All the technological advances in production of food, energy and materials will not be able to cope with the growth of population. The most urgent need, therefore, is a cheap, simple method of birth control—and it is not in sight. This, and the lack of a world-wide system of economic planning, remain the two main barriers to the advance in living standards that is scientifically possible.

On the Shelf

By Frank H. Smith

There are probably few trades in which the apprentice has so much chance of becoming his own master as the building trade. In every town of any size there are prosperous builders driving about in Jaguars whom their contemporaries remember as starting as bricklayers or plasterers.

Unfortunately, they usually come up the "hard way" and few of them have the real technical outlook. By the same token, few of them know of a service such as is provided by the Building Research Station.

This musing is prompted by the sight of No. 100 of the *Building Research Station Digest* which consists of an index of the first one hundred *Digests* and a lecturette entitled "Taking Stock." This little piece should be made compulsory reading for builders from the heights of those who are engaged on projects provided with public observation platforms to those who carry out repairs to semi-detached suburban villas. It should be distributed on the same basis as the *Highway Code*. As a model of common sense applied to information dissemination it should be read by librarians and information officers everywhere.

The resources of the Building Research Station are summarised and explained and the accompanying index is an indication of the mass of information and help available. Among the numerous subjects indexed are dry rot, smoky chimneys, human sensitivity to vibration, sound insulation and concrete rust stains. The index costs 5*d.*, post free, from Her Majesty's Stationery Office, and if you want to send them to friends, 25 cost 5*s.* 6*d.*

If, on the other hand, you wish to undertake a task like blowing up the Möhne Dam, the Building Research Station can advise you on that. It will take a little longer, that's all.

In these days of "Do it yourself," the possession of this leaflet can save you the expenditure of pounds on handicraft books, besides probably helping you to do a job for which you would otherwise have to call in a grudging builder.

I believe that, on previous occasions, I have referred to the mass of printed matter turned out by the United States Government Printing Office. One of their latest publications is *National Bureau of Standards Circular* 562, *Supplement* 1. This is their *Bibliography of Research on Deuterium and Tritium Compounds*, 1953 *and* 1954, and it costs 25 cents (H.M.S.O. will get it for you). The original publication, to which this is a supplement, covered the years 1945-52. The present 1953-54 document contains 720 references in three sections. The first section consists of a bibliography and author index and the next two sections comprise subject and compound indexes respectively. "Atomic Energists" will know what it is all about.

FIRST LESSONS IN SOIL MECHANICS

Landslides in Clays. By ALEXANDRE COLLIN, 1846. Translated by W. R. SCHRIEVER. *University of Toronto Press and Oxford University Press, Amen House, Warwick-square, London, E.C.4.* (52*s.*)

Soil mechanics is usually regarded as a comparatively modern branch of engineering science, although the pioneer work of Coulomb, nearly 200 years ago, still forms the foundation of our present-day knowledge of the shear strength of soil. It is only in the present century that the concept of effective pressures and improved techniques of sampling and testing have demonstrated the real meaning of Coulomb's principle, enabling it to be applied usefully in engineering practice. The intervening period was marked by the publication of various mathematical theories, chiefly concerned with the pressure on retaining walls and by spasmodic experiments, in many of which the practical limitations were not fully realised. It was during this period that Alexandre Collin made a special study of clay banks, and in 1846 he published the book *Recherches Expérimentales sur les Glissements Spontanés des Terrains Argileux*, the translation of which forms the subject of this review.

The translation of this remarkable book into English was sponsored by Mr. Robert F. Leggett, now director of building research, National Research Council, Canada, and the translation was carried out by Mr. W. R. Schriever.

The translation of the text is preceded by a memoir entitled "Alexandre Collin and His

Pioneer Work in Soil Mechanics," by Professor A. W. Skempton. The book itself contains case records of 15 slips in banks with which Collin had been associated. Several of these occurred in the banks of the Bourgogne Canal and its reservoirs, where he was employed as engineer. From these observations he deduced that the slip surfaces took the form of cycloidal arcs. The author goes on to describe methods of repairing such slips. He then describes some experiments to determine the properties of clay soils, and discusses the classical earth-pressure theory of Coulomb, which he does not consider applicable to the stability of clay slopes. In a note at the end of the book Collin presents an attempt to calculate the resistance to sliding of a clay bank. This is of particular interest as some 70 years were to elapse before the first circular slip analysis of the stability of a clay slope was published by Petterson.

The original French text was in the literary style of the period, characterised by very long sentences. The translator has endeavoured to remedy this and yet to maintain close adherence to the French text. The result is a book which, it must be admitted, is somewhat heavy reading. The diagrams have been reproduced photographically from the original work. The reduction in size of these beautifully executed drawings has unfortunately resulted in very fine lines and printing which is rather difficult to read. The original title page is reproduced; the wording of the sub-title " accompagnés de considerations sur quelques principes de la mécanique terrestre " is significant.

Recent years have witnessed growing interest in the history of science and of its application to engineering. Collin's book is indeed one of the classics of civil engineering literature, and will appeal to all who study the history of soil mechanics and, indeed, of civil engineering construction.

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NEW BOOKS

Mathematical Notes. By C. F. G. MacDermott. *Blackie and Sons Limited, 17 Stanhope-street, Glasgow, C.4.* (3*s.* 6*d.*)

These notes, compiled by an experienced teacher, are intended to help students proceeding beyond the " O " level stage and beginning their preliminary professional scientific and engineering studies.

The facts and formulae listed are accompanied, in most cases, by an outline of their proofs. The sections deal, respectively, with algebra, plane co-ordinate geometry, calculus, projective geometry, trigonometry, statics, hydrostatics and dynamics. Each section is divided into numbered paragraphs and blank pages are provided for additional notes. On page 51, *g* has been omitted from the expression for the pressure. This handy little collection of results in elementary pure and applied mathematics should prove useful for reference and revision.

Tin Box Manufacture. By J. W. Langton. *Canning Publications, 14-15 Coleman-street, London, E.C.2.* (30*s.*)

" Tin " boxes, which of course are not made of tin, but of tin-plate or aluminium sheet, are familiar to everyone, and the misnomer by which they are known is too well established to be altered. The tin box industry is small in comparison with industry generally, but its output is large, and to produce the great numbers of boxes required it is necessary to use high-speed machinery. Some of this is orthodox in principle, and some is of special-purpose design; power presses are the main machines in the first group, while the special-purpose class includes such items as trimming and beading, body forming, seaming and soldering machines. On the former it is possible to obtain standard data without difficulty, but the latter types are more obscure. Even in the case of power presses special tooling is often necessary.

Information on special-purpose machines and on the special tools needed for power press work is difficult to obtain, and it is to remedy this defect that the present work, claimed to be the first book on its particular subject, has been written. Following a logical sequence beginning with raw material selection and testing, the book proceeds to deal with material preparation, tooling and maintenance. Nearly half the book is devoted to special-purpose machines. It is illustrated with both line drawings and photographs.

Management

Weekly Survey

Autumn Fashions

The summer schools are over and the technical and management colleges are returning for the autumn term. Boards, management committees and works councils will soon be in their stride at the end of the holiday season. As each summer comes to an end the opportunities for educating management and the scope of courses, isolated lectures and training schemes grow ever larger. It is a sign of the times, and one to be applauded, that management (be it art, innate ability or acquired knowledge) is being systematically taught and learned as never before.

It is important, however, that what is intrinsically a sound development should not be overlaid with an ephemeral fashion trend. It is much to be desired that leaders in British industry and the younger men who will one day take over from them should think logically and form an adequate knowledge of the facts in making business decisions. It is important, nevertheless, to avoid falling into the opposite trap of imagining that commercial enterprise consists to a large extent of logical thinking from an academic background and the proliferation of committees. Both these are very important but they can be mis-used. Some companies are finding that the vogue to recruit brilliant men with a non-commercial background can go too far and some have discovered that not all men who can think clearly in committee have the flare to take the right decision at the right time without the support of a team of colleagues. All companies need a judicious mixture of intuition, business experience and acumen and disciplined thinking. The big problem for boards and top management is to organise their administration so that their company gets the best of both worlds.

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Chairmen as Crystal Gazers

The very good results of the George Cohen 600 Group Limited for the year ended March 31 draw attention once more to the problem of forecasting results. Cohens achieved a 25 per cent. increase in group trading profits although a year ago the board was looking forward to no more than a repetition of the previous year's results. The chairman on this occasion made another cautious statement on the prospects for the new financial year.

There is constant pressure from shareholders' interests these days to give detailed and frequent forecasts about the prospects of companies. In many ways this is an excellent development, for it cuts down uninformed rumour and the less desirable forms of speculation. On the other hand it puts a severe strain upon the boards of companies, for they are asked to take a view on an exceedingly complex and changing picture. Inevitably, they tend towards caution if for no other reason than the excellent common-sense attitude that it is better to make a conservative forecast which events prove to be an under-estimate than to be boldly optimistic and wrong in the event. The fact is that the desire for information and the need to take a view is running ahead of the techniques for forecasting which most companies are prepared to use.

There are some large companies whose forecasting exercises, so it is claimed, enable them to estimate their turnover figure in an incoming financial year to within 1 per cent. To go a stage further and estimate profits is to have to deal with yet another group of variables and it follows that few who cannot make a fairly accurate forecast on turnover can be expected to make a close estimate on profits. The fact is that pressure to crystal gaze on profits is in the end pressure to make full use of all modern statistical means of forecasting future performance, including budgetary control of current and capital expenditure (and also sales), regular and intelligent collation and interpretation of internal and trade statistics and an appreciation of general economic factors. All this mass of economic and accounting data has to be woven into an already complicated technical picture.

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Machine Tool Outlook

Recent statements by the chairmen of machine-tool companies have in common a certain cheerfulness concerning prospects. No one appears very depressed, and the point of view put forward by Mr. A. G. B. Owen—in his capacity as chairman of the Brook Tool Manufacturing Company—reflects the general feeling in the industry: " I think we may safely anticipate some improvement in the trading results for the current year and, whilst I regard the future with a measure of confidence, we are once again faced with increases in wages, salaries, raw materials and supplies of every kind and the long-term prospects are extremely difficult to forecast."

Sir Stanley Rawson, chairman of Wickman Limited, reported a successful year, with a larger turnover and higher profits despite lower profit margins. He mentioned particularly the higher selling expenses involved in " intensified effort in export markets." Sir Stanley's review of prospects was even more cheerful than Mr. Owen's: the heavy backlog of orders had been reduced and the recession in the motor trade had caused postponements of a number of schemes of reconstruction and re-equipment, but in spite of this " the volume of orders in hand and being received ensures that the company's prospects for the current year are good."

Other reports show the same confidence. The chairman of Charles Churchill, Mr. J. B. S. Gabriel, saw no reason to be " other than cautiously optimistic " and expected " a more peaceful period in industry." Mr. Douglas Sharp, chairman of the Scottish Machine Tool Corporation, mentioned that export business had " practically doubled over the previous year " and was confident that his company would enjoy their share " of success in the industry." Mr. W. D. Gibbs, chairman of Ada (Halifax), was even more emphatic when he told shareholders that " in the view of your directors the prospects for the future are good."

* * *

Safety Regulations in Engineering

The Industrial Safety Division of the Royal Society for the Prevention of Accidents are publishing a series of safety manuals under the title of " I.C.I. Codes and Regulations (Safety)." I.C.I. first prepared a series of engineering safety standards for use within their own organisation during the period 1933 to 1935. These attempted to show how the best technical knowledge then available could be applied, having regard to existing factory legislation, and the company found that they were of material assistance in reducing the accident frequency rate to less than half its former level. They therefore decided to revise and extend these safety standards.

The latest booklet in the series covers safety in relation to electrical engineering in chemical factories, and contains in ready reference form extracts from relevant legislation and other regulations as well as miscellaneous memoranda. Other codes in the series cover electrical plant installation; electrical portable and transportable plant equipment; design, layout and installation of machines; construction and maintenance (mechanical engineering) and lifting appliances; sites and services; building structures; railways and haulage; docks, wharves and quays; and road transport of plant.

Marketing

PROMOTING EXPORTS

Many more British companies are taking special steps to increase their exports, particularly to North America. Rolls-Royce recently announced a big sales promotion drive in the United States which will include sending a caravan of 23 cars on a tour of Texas. Dealers will be appointed in the area and an advertising campaign launched in the local Press. Already, sales have expanded very satisfactorily over the past few years: in 1956 they were double the 1955 level and in seven months of this year had equalled last year's total. This is an impressive performance and, if the rate of expansion is maintained, over one-fifth of all cars made in 1957 will have been sold in the United States.

Other companies have been setting up or improving their overseas sales organisations. Thermotank Limited, who make air conditioning, heating and ventilating products, have formed an International Products Division with world-wide representation. The division will be "truly international" and among the reasons for forming it was "the possibility of a common market" and "the greater opportunities which would then exist for the exchange of products throughout the Continent."

Monsanto Chemicals, under the leadership of a great salesman, Sir Miles Thomas, are developing the pattern of their internal organisation "to meet the requirements of the continued growth of their business and their current programme of expansion." The activities of the company are being decentralised into two divisions, chemicals and plastics, which is expected, *inter alia*, to "increase the efficiency of customer and after-sales service."

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Holding the Germans Back

Germany's export surplus has become almost as big and intractable a problem as our own trade deficit. It has for some time been the Government's policy to discourage further expansion. The latest step has been taken by the Deutsche Bundesbank, who have excluded so-called export drafts from rediscount facilities. They have also decided to modify rediscount terms for foreign bills and foreign acceptances.

The effect of these decisions will be to increase the cost and the risk of export business for the exporter. Banks will now be more reluctant to buy export drafts, which will have to be replaced by more costly overdraft credit, and the Bundesbank will cease to bear the whole of the currency risk as they did when they discounted these drafts at the exchange rate ruling when they accepted them.

These changes are not expected to come into force until early next year and will affect no more than 10 per cent. of all German exports. The problem of an export surplus will require more violent measures: as one of Germany's leading makers of gudgeon pins was heard to remark at the Farnborough Air Display—German manufacturers have no opportunity to sell enough of what they make in so small an area, they have not enough "liebestraum"—a word most of us have heard before.

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New Sales Approach in Cars—U.K.

The decision of the British Motor Corporation not to bring out new models annually represents a major change in car sales promotion technique, and the first important departure from American practice. There is little doubt that the great and prolonged success of single models, such as the Citroen 12CV and 15CV and the Volkswagen, have proved that a successful design will find world-wide acceptance for a decade or more. The pre-requisite, of course, is that it should be a model with a distinctive appearance and character. For this reason, therefore, it may prove necessary to simplify a company's range until the whole of their energies and resources are concentrated upon one style. Sir Leonard Lord's remark that "it is felt, and indeed this feature is confirmed by world-wide demand, that the whole range of B.M.C. cars is widely competitive in appearance, performance and price" suggests that B.M.C. will not change their policy of making a wide range of models to suit different tastes and pockets.

Sir Leonard said that in future they would bring out new models "as and when market conditions warrant." This could mean almost as frequently as before except, of course, that the date of the change could be kept secret so that old model sales do not tail off in the expectation of new models in October.

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New Sales Approach in Cars—U.S.A.

The American car industry has taken a hand in the fight against road accidents, which may make selling cars a great deal harder. A few weeks ago the Automobile Manufacturers Association announced that the industry would in future "emphasise useful power and safe, reliable and comfortable transportation . . . rather than capacity for speed." Already Ford have issued a directive to their dealers which has been greeted with amazement. It goes so far as to forbid the lending of cars to the motor magazines for testing purposes.

Among the many far-reaching consequences of the new policy will be the winding up of contracts between car firms and professional racing motorists. Both Ford and Chevrolet had budgeted some 3 million dols. this year for racing and special events. There is unlikely to be any more organised racing and certainly the use of the results in publicity—extensive since the war—will cease.

The aim of the campaign is to educate the motoring public into a different scale of preferences, and to kill the glamour of speed Manufacturers have for long pointed out that while top speeds have increased, as have fatal accidents, the rise in speed capability—from, say, 90 to 100 m.p.h.—has been more than matched by increased safety. It is also a fact that most accidents occur at speeds of less than 45 m.p.h. Yet it cannot do harm to replace "speed" by "safety" in advertising cars. It is the effect on the motorist's outlook rather than on the design of cars which is to be looked for.

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Canada's Trade

The growth of the Canadian economy continues to surprise the world, as did for many years Australia's capacity to import cars. The dominant part played by the United States in Canadian trade, however, has tended to frighten off a good many British manufacturers who might do very well in that Dominion.

Last year Canada led the world in trade *per capita*—i.e., the value of imports and exports per person. The annual review of foreign trade published by the Dominion Bureau of Statistics states that Canada was second to New Zealand in 1954 and 1955, but sharply increased imports last year as a result of a heavy capital investment programme, while New Zealand had to impose restrictions for currency reasons. Total Canadian exports rose by 12 per cent. and imports by 21 per cent. to give Canada nearly 6 per cent. of world trade. This is surpassed only by the United States, the United Kingdom and Western Germany.

Last year the British market took 16·8 per cent. of Canadian exports and supplied 8·5 per cent. of imports. The corresponding figures for the United States were 59·2 and 73·0 per cent. The scope for an improvement in the British position remains immense.

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Latin America's Future

The aspirations of Latin American countries, particularly in the direction of industrial expansion and military strength, were criticised by leading United States representatives at the Inter-American Economic Conference begun in Buenos Aires last month. Basically, all were for increased United States aid and there was disappointment when the United States Secretary of the Treasury, Mr. Anderson, said that his Government were not intending to assume the rôle of a benefactor. He suggested that Latin American countries should look to the private investor rather than to the United States Treasury, and should therefore make efforts to attract him.

The refusal of the United States Government to participate in the proposed Inter-American Bank or Development Fund was a source of disillusionment, as was their aloofness from a proposal for a common, or regional, market. It is clear that the United States wish to preserve the freedom of action on a world basis and avoid any commitment likely to prove restrictive. On the other hand, it is in the interest of the United States that Latin American expansion should go on, and for this reason the Export-Import Bank will doubtless step in with increased loans if necessary. The quality of national and private administration and management in most of the countries concerned is the main cause for the present difficulties and conflicts. Nonetheless, the implication of what has taken place so far, and of the conference's agenda, is that the United States will perforce play an increasing part in Latin-American development.

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The Indians in India

For several months now Indians have been talking of their second five-year plan as if the whole future of their country depended on it. The lack of capital to finance the scheme has led to a variety of proposals, "phasing" being the latest. Meanwhile, the search for capital goes on. The Indian Finance Minister, Mr. T. T. Krishnamachari, is due in the United States shortly where he is expected to find a great deal of support. The possibility of raising loans on the London market has been ruled out for the moment for, the Minister said, "we do not approach a market for a loan unless we are certain of an encouraging response." In fact, the Indians need foreign capital but have no love for it, whether its source is the United States, the Soviet Union or Britain. The spirit that moves them is conveyed very well by an article published in *India News* of August 24. The author is Mr. P. C. Mukergie, member (engineering), Railway Board of India. The title is expressive enough: "Railways—the Goal to Self Sufficiency."

The pride with which Mr. Mukergie relates the "quite remarkable" progress that has been made in the development of manufacturing facilities for wagons, carriages, locomotives and the building up of ancillary industries is unmistakable. This appears to have been done well and progress has been rapid. While it is realised that the task in the second plan is more difficult than has ever been undertaken, the way in which they are going about the job, the considerable stress laid on research and development, the benefits derived from foreign knowledge and experience (and from British work in India before partition), the development of standards, the training of engineers—all appear to add up to a good start.

Research and Development

COMPUTING IN THE MODERN WORLD*

By Andrew Booth, D.SC., PH.D.†

It is proposed, in the present paper, to discuss briefly four aspects of the modern electronic digital computer in its relation to the world at large. These can be described under the headings: non-numerical, commerce, engineering, and science.

Before entering on the technical discussion, however, it will be well to explain what is meant by the term "digital computer." Essentially the major units are those shown in Fig. 1. There is an arithmetical unit, which is capable of adding, subtracting, multiplying and dividing; a store or memory, which is capable of holding information that includes the interim and final results of the calculation and also the programme instructions for the computing machine; and a control, which orders the operations of the arithmetical unit to perform the calculations required. It will be seen that there is a connection from the store to the control, indicating that, as is customary in most modern machines, the control receives its information from the store in the same way as does the arithmetical unit. There is also an input line to the arithmetical unit from the control. This should be obvious in its purpose: it transmits instructions to the arithmetical unit. The need for a second line, from the arithmetical unit to the control, is perhaps not as obvious. It is the means which the machine has of ordering its operations in the light of the results of the calculations already performed.

There are, in addition, two parts which have at times been omitted: the input and the output. These take the form of punched cards or tape, or magnetic tape, for input and of punched or magnetic tape or punched cards, or even a typewriter, for the output.

Fig. 2 shows a magnetic drum store.[1] It is that associated with our own computer, A.P.E.X.C.[2] at the Birkbeck College Computational Laboratory and it consists of a cylinder of magnesium-zirconium, 1¼ in. long and 5 in. in diameter, coated with an iron oxide/plastic dispersion. On the periphery are 32 magnetic read-record heads arranged in eight rows, four on each side. The drum rotates at 3,000 r.p.m. and the access time is 1/50 sec. in the worst case.

Fig. 3 shows the computing machine A.P.E.X.C. which, whilst probably the smallest computer in existence, is by no means the smallest in capacity. It may be noted that under suitable conditions of optimum programming, its arithmetical speed is comparable with that of the very much larger machine E.D.S.A.C. (I) at Cambridge.

* Paper read before Section G of the British Association at Dublin, on Tuesday, September 10, 1957.

† Director, Birkbeck College Computational Laboratory, University of London.

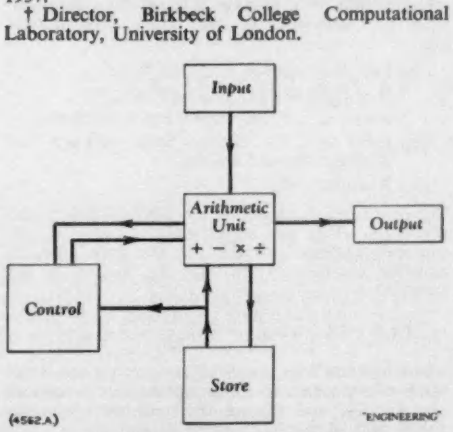

Fig. 1 A digital computer can be considered as made up of three major units together with input and output facilities. The diagram shows the relation between the units.

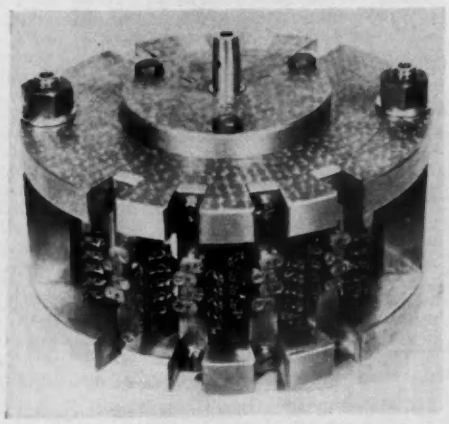

Fig. 2 Information is stored on the surface of a rotating drum. Access to the information is gained through a number of read-record heads.

TRANSLATING LANGUAGES

The first of the computing-machine applications with which it is proposed to deal is that of the machine translation of language[3]. Here is an application which is superficially quite non-numerical. In fact, of course, it turns out that to translate languages at all on a computing machine the words must first be turned into numbers. Most readers will be familiar with teletype and with what happens with the depression of the typewriter key; first a printed slip appears and secondly a punched tape or set of electrical impulses are generated. The tape is almost invariably punched in the five-hole international code. Thus any row on the tape represents a number in the binary scale in the range 0-31.

If a message in any language is punched on to a tape it is in numerical form, and it is therefore suitable for processing by the digital computer. The first proposition is to look up the foreign language word in a dictionary. There are, however, all sorts of difficulties which must be glossed over in such a short lecture as this. One is that normal dictionaries are no good at all for computing machines, because the normal dictionary implies that the user has some knowledge of the structure of the language. For example, the word *cherchez* would not be found, instead the infinitive—*chercher*—is present which would not be intelligible to a machine capable only of direct comparison. To overcome this difficulty the machine is used to store dictionary stems, which are defined as being the longest part of the foreign word that is common to all inflexions of the word. This poses no problem of principle but merely one of storage. (In the case of irregular verbs, or any other words of irregular structure, more than one stem or even all the various parts of highly irregular structures may have to be stored.)

The next problem is that of actually looking up the word. The most elementary and straightforward method is to take the number which represents the foreign language word and look up the equivalent in the storage position bearing that number but, in fact, even with restriction to words having a length no greater than ten letters, the number of possible storage positions is 26^{10} ($= 1{\cdot}4 \times 10^{14}$). No known storage device has this capacity, and the method is, in any case, grossly redundant.

A second technique is to store foreign language words and the English equivalents alongside one another in consecutive storage locations in the dictionary. The look-up process is simple; it is that of comparing the unknown foreign word with that of the foreign language entries in the dictionary, one at a time.

Considering these entries as numbers and assuming that the code is A = 1 and B = 2, etc., then the foreign language entries are in ascending order of magnitude. If the unknown foreign language word is subtracted from the foreign language entry, the result will be negative until the stem is reached and positive thereafter. At this point the machine can tell that the entry corresponding to our foreign language word has been located. This process, which involves on the average looking at one half of the words in the dictionary to find any unknown word, is quite inefficient.

The latest technique is to compare the unknown word with the entry half way through the dictionary. The wanted translation is thus found to lie either in the first or the second half of the dictionary; if the former a new comparison is made with the word at D/4, if the latter at 3D/4. Here, D is the total number of words in the dictionary, and it is easy to show that the word will be located in about $\log_2 D$ operations. The merit of this method becomes clear when it is remarked that the earlier methods involve, for a dictionary of 100,000 words, about 50,000 comparisons to find an unknown word, while the partitioning technique requires only 17.

Having located the foreign language word, there is read out from the storage location the English equivalent expression. In fact, this is an English stem. After this initial operation, use is made of the foreign language ending, which remains over when the stem has been removed, in order to derive an English ending which is put on to the English word. Thereafter a decent English text is produced.

Other operations such as arranging for idioms, resolving ambiguity and rearranging the order of words in a sentence in cases of such languages as German, must be performed, but since they follow straightforward computation principles based on the use of the discrimination processes between positive

Fig. 3 The A.P.E.X.C. all-purpose digital computer is a small machine arranged for ease of experiment.

and negative of the sort common in computer programming, enough has probably been said to make the process clear.

DECIDING STOCK BUYING POLICY

The classical problem which presents itself to the buyer of a large commercial organisation is that of obtaining outside supplies in such a manner as to minimise the total cost to the company. This minimisation can be achieved in a number of ways, many of which have to be operated in parallel. Possibly the most obvious consideration, from the point of view of the buyer, is that of obtaining discount, and in general a larger discount is obtained for batches of considerable size than is available when ordering smaller quantities. On the other hand, if large quantities of stock are to be purchased at one time then the company must provide storage space for the articles and this storage space can be looked upon as invested capital. These are two of the parameters which must be considered when the problem of optimum stores buying is considered. A study of the problem from the point of view of the computing machine has been made in the Birkbeck Computational Laboratory. A simple presentation follows.

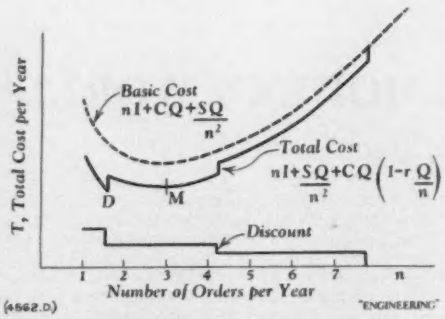

Fig. 4 When the discount for bulk purchases is a discontinuous function, the optimum number of orders for stock does not necessarily occur at the point (M) predicted by calculus.

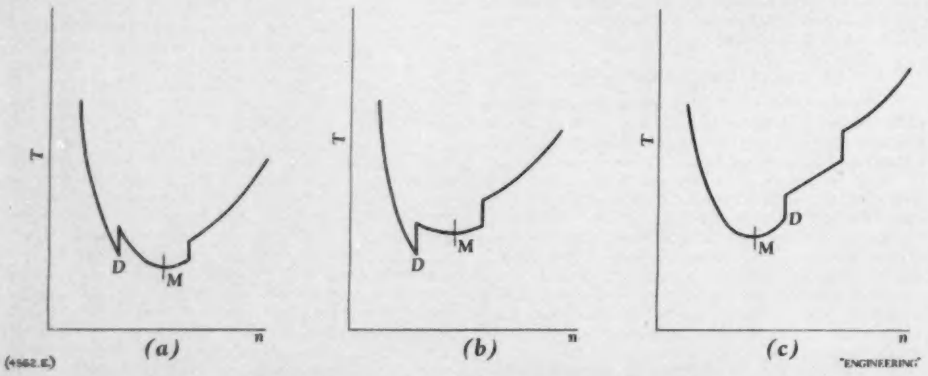

Fig. 5 Three solutions are of importance when the cost is a discontinuous function. In the cases (a) and (c) the minimum, M, is that predicted by calculus. In (b) it is at the point of discontinuity.

Let Q = total quantity of stock to be ordered during the year
C = cost per unit quantity of stock
S = cost of storage per unit quantity of stock per annum
I = cost of initiating an order
n = number of orders initiated during the year
r = percentage discount for unit of stock
T = total cost of operation per annum.

Then,

$$T = nI + \frac{SQ}{n^2} + CQ\left\{1 - r\left(\frac{Q}{n}\right)\right\}$$

If it is assumed that $r\left(\frac{Q}{n}\right) = r\frac{Q}{n}$

$$T = nI + CQ + \frac{Q}{n}\left(\frac{S}{n} - CQr\right).$$

For minimum cost $\frac{dT}{dn} = 0$

i.e., $$I - \frac{Q}{n^2}\left(\frac{2S}{n} - CQr\right) = 0.$$

And, for a real minimum, $\frac{d^2T}{dn^2} > 0$

so that $$3nS > CQr.$$

In practice the quantity $r\left(\frac{Q}{n}\right)$, which represents the discount for bulk purchase, will be a discontinuous function whose value is, say, 5 per cent. for $\frac{Q}{n}$ between 10 and 100 and 15 per cent. for $\frac{Q}{n}$ between 100 and 1,000.

The effect of this upon the solution is as follows. $T = nI + \frac{SQ}{n^2} + CQ$ is taken as the basic solution. This expression is shown in the graph, Fig. 4, by the continuous curve. The discount factor $CQr\left(\frac{Q}{n}\right)$ is shown by the stepped line, and the resultant by the discontinuous curve. It is clear that the optimum value, in the case illustrated, occurs at D and not at the point M predicted originally.

Three situations are of importance and these are shown in Fig. 5. In cases (*a*) and (*c*) the minimum, M, is that predicted by calculus; whereas that in (*b*) is at the discontinuity point D. Because of these discontinuities it appears that the problem is best solved on an electronic computing machine by the following method:

(1) Calculate T (n)
(2) Calculate T ($n + 1$)
(3) Determined T ($n + 1$) − T (n) = d
(4) If $d < 0$ store ($n + 1$) and T ($n + 1$), if $d \geqslant 0$ store (n) and T (n)
(5) Proceed to ($n + 2$), comparing this with the value just stored.

The programme is started at $n = 1$ and stopped at, say, $n = 12$. The stored results give the value of T (n) and the optimum value of n.

Notice that the result may not be unique if D and M have the same value of T; both can be found with this programme if it is considered necessary.

This treatment is based on a simplified model and is merely given here to illustrate the way in which the programme has to be organised. In reality, because money has been used to purchase components, it will not be available for accumulating at compound interest as would normally happen with company capital under sound financial direction. In addition to this, the programme just described deals only with stock of a particular sort, and the problem must be extended to cover the case where a given storage space is available to be distributed in the most economical manner between all the components which have to be bought. At this stage the problem becomes one of considerable magnitude in which the discontinuities which are involved in the discount rates make a rigorous analytic solution quite impracticable. On the other hand by the use of certain self-evident considerations, the simple programme just outlined can be made to improve greatly the buying operations of a company.

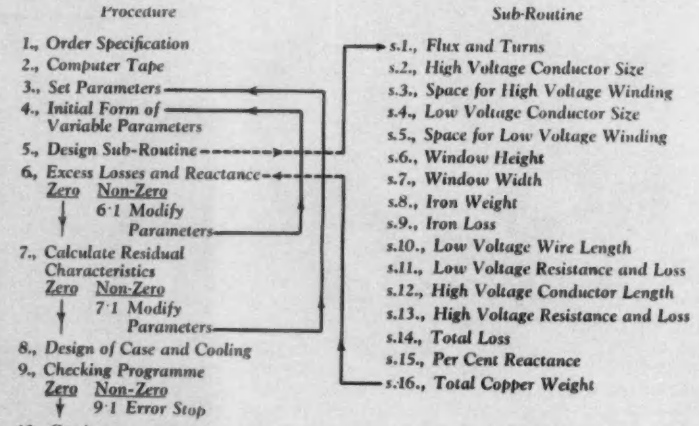

Fig. 6 In the sequence of operations of a computer used for designing a transformer, the adjustable parameters are flux density, current density, core area, and window size. The whole process can be completed in about four seconds on a medium-speed computer.

DESIGNING TRANSFORMERS

The use of an automatic digital computer to design 50 c/s power transformers appears originally to have been examined by Humphrey Davies and his associates.[4] The programme which they constructed works in the following way. It is assumed that the machine is supplied with the purchasers' specifications and with an initial estimate of the core area for the desired transformer. The machine calculates the number of turns on the low-voltage winding from the well-known formula:

$$N = \frac{k_1 V}{k_0 A B f}$$

where k_1 is a scaling constant

V the voltage applied to the winding
k_0 the core space factor
A the assumed core area
B the assumed working flux density, and
f the operating frequency.

In general N will not turn out to be a whole number, so that the machine has to take the nearest integer to it and re-calculate the flux density. On the basis of this integer approximation to N, the number of turns on the high-voltage winding can be evaluated by using the known transformation ratio specified by the customer.

Once these basic quantities are known, the next step is the calculation, from the known conductor sizes, of the window dimensions of the laminations; this is followed by an estimation of the weight of active iron, W, in the core.

At this point the first cycle of the design process is complete and the next stage is to estimate the excellence (or otherwise) of the result. The criteria are:

(i) Iron loss, derived from the formula
$P = W(a_1 B + a_2 B^2 + a_3 B^3 + a_4 B^4)$
where $a_1 \ldots a_4$ are known loss coefficients
(ii) Load loss, Q, derived from currents and winding sizes and lengths
(iii) Reactance, R.

The quantities, P, Q, and R are then compared with the values which they should have in order to meet the specification. If necessary, the core area, A, assumed initially, is modified by means of the formula:

$$\Delta A = A\left[\alpha\,\Delta\frac{P}{P_d} + \beta\,\Delta\frac{Q}{Qd} + \delta\,\Delta\frac{R}{R_d}\right]$$

where α, β and δ are weighting constants, chosen as a result of experience to ensure optimum convergence; and P_d, Q_d, and R_d are the customer's specified values of P, Q and R.

As soon as satisfactory values for the loss functions have been obtained, a final set of residual characteristics is evaluated and from this, if necessary, modifications are made to pre-set such parameters as the core material and the winding type and layout.

Finally the machine calculates the arrangement of

Continuing Research and Development

windings and core, costs, tank size and so on, ending with an overall check to ensure that no mistakes have crept in. It is interesting to note that about three cycles of refinement are usually required to bring the losses within ± 2 per cent. of those specified, and that the whole process can be completed in about four seconds on a medium-speed computer.

The sequence of operations followed by the machine is outlined in Fig. 6, which is self explanatory except that the pre-set parameters are: type of winding, type of core material, and mechanical construction; and the adjustable parameters are: flux density, current density, core area, and window size.

CALCULATING CRYSTAL STRUCTURE

An important branch of physical research deals with the determination of the molecular structure of crystalline materials.[5] Here the basic data are a set of observed "structure factor amplitudes," $|Fo(h, k, l)|$ which are simply related to the intensities of the X-ray reflections obtained during diffraction measurements on single crystals.

The quantities h, k, l are simple whole numbers, known as Miller Indices. They usually lie in the range 0-100.

It was shown by the Braggs that crystals could be considered to be built up of a large number of elementary building blocks—or "unit cells"—each of which is an identical copy of the others. Under these conditions the structure can be considered to be periodic, so that a Fourier expansion should be possible for the expression of the electron-density variations from cell to cell. It can be shown that, if the unit cell is assumed to have axial dimensions a, b, c and if x, y, z are the co-ordinates of any point inside that cell, then the density of electrons $\rho(x, y, z)$ is given by the triple Fourier series:

$$\rho(x,y,z) = \frac{1}{V} \sum_{h,k,l=-\infty}^{+\infty} \sum |F_0(h,k,l)| \times \cos\left\{2\pi\left(\frac{hx}{a}+\frac{ky}{b}+\frac{lz}{c}\right) - \alpha_{hkl}\right\} \quad \ldots (1)$$

In this expression V is the volume of the unit cell and α_{hkl} is a phase angle which cannot, in general, be determined experimentally. If α_{hkl} were determinable from experiment a direct calculation of $\rho(x, y, z)$ could be made since the $|F_0(h, k, l)|$ are known, the calculations though tedious would then be well within the range of human calculators. In practice, however, an indirect approach must be adopted.

It turns out, however, that

$$F^2(h\,k\,l) = A^2 + B^2$$

where

$$A = \sum_{r=1}^{N} f_r \cos 2\pi\left(\frac{h x_r}{a}+\frac{k y_r}{b}+\frac{l z_r}{c}\right)$$

$$B = \sum_{r=1}^{N} f_r \sin 2\pi\left(\frac{h x_r}{a}+\frac{k y_r}{b}+\frac{l z_r}{c}\right)$$

and

$$\tan \alpha_{hkl} = \frac{B}{A}.$$

Here f_r is an atomic scattering factor, which is known from wave-mechanical considerations, and x_r, y_r, z_r are the co-ordinates of the centre of the rth atom of the N which make up the structure. Thus, if approximate co-ordinates are known, an approximate value of α can be calculated and it can be shown that the substitution of this in equation (1) with the experimentally determined $|Fo(h,k,l)|$, and the subsequent location of maxima in electron density leads to an improved set of values for x_r, y_r, z_r. Repetitions of the process lead to convergence to very accurate atomic co-ordinates.

The whole process may be exhibited in cyclic form:

(1) Rough approximations to x_r, y_r, z_r
(2) Compute α_{hkl}
(3) Locate maxima in $\rho(x, y, z)$ using $|F_0(h,k,l)|$ and α_{hkl}
(4) Compute $|F_{calc.}(h, k, l)|$ using maxima found in (3)
(5) Calculate discriminating function
(6) (*a*) If unacceptable repeat from (1) using the co-ordinates found in (3)
(*b*) If acceptable print out co-ordinates and stop.

The only point which requires explanation is (5). The discriminating function is

$$R = \frac{\sum_{hkl} ||Fo(h,k,l)| - |F_{calc.}(h,k,l)||}{\sum_{hkl} |Fo(h,k,l)|}$$

which can be shown to approach 0·15 to 0·20 as the process converges to the solution required.

The operations described are all ideally suited to a computing machine and it is only necessary to mention that the time for processing a complete structure of moderate complexity (20 distinct atoms, say) has been reduced from 3 years to as many weeks. In fact the actual computing time is now far smaller than the time required to obtain the experimental data and to do the preliminary and incidental "thinking." This thinking is still important since, despite popular utterances to the contrary, the computer is not yet within sight of replacing the scientist!

CONCLUSION

These brief examples will have shown the great versatility of the modern computing machine and the reader may well ask where the development is leading. Prophecy is always dangerous but two things stand out: firstly that the cardinal problem which remains to be resolved is that of programming learning from experience and creative thought, and secondly that progress, even if restricted to the present low-grade mental activities of the machine, will soon lead to the replacement of armies of clerks and routine factory and design staff. The social implications of these changes are outside our terms of reference.

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ENERGY AND POWER SUPPLY*

By Sir Josiah Eccles†

In any discussion on energy and power supply it is necessary to have in mind what energy means to modern civilisation. Perhaps it is not putting the matter too highly to say that the well-being of the great mass of people to-day, contrasted with the low standard of living which once prevailed, is due to the increase in the availability and utilisation of energy. To appreciate this point let us take a quick look at life in times past.

It is difficult to say with certainty what conditions were like in earliest times, but for our purpose it is unnecessary to go back further than 10,000 B.C., about which period some information has been preserved. The picture we can conjure up is one of an unceasing struggle against nature; life was short, there was little leisure and no organised medical service. The release from this thraldom was a very gradual process which began with man's efforts to combat the hazards of his environment by enlisting the forces of nature, and constraining them to do his bidding. To use a metaphor, man had now begun to swim with the stream instead of dissipating his substance in battling against it.

The first discernible steps were the extended use of fire and the bringing under control of animal power and its substitution in large measure for human brawn. Even so, at this stage of development animal power was confined mainly to the transportation of man and materials. As yet the strongest force in being was that of one or more elephants. The use of wood to make fires was followed by the fashioning of elementary tools from heated and beaten metals, and by the baking of clay for utensils. There followed the gradual utilisation of the force of gravity, and of wind and water power in conjunction with the development of the wheel, the latter perhaps ranking as one of the most important inventions of all time.

The centuries until the industrial revolution in Britain produced no noteworthy new means of utilising energy but were characterised by steady but slow development of wind, water and human—or animal—powered machines of simple mechanical advantage. The scale of energy usage was still small.

The advent of the steam engine, invented by Thomas Savery and improved by Newcomen and Watt, and, shortly afterwards, the internal combustion engine, first introduced by Daimler in 1885, revolutionised economic and social life in Britain. The pattern of energy usage was no longer restricted to substituting a certain amount of mechanical power for human and animal muscle but was expanded to make possible projects and processes that had been impracticable hitherto. The introduction of steam power stimulated the demand for coal and was given its greatest impetus by the invention in 1884 by Charles (later Sir Charles) Parsons of the steam turbine, leading to notable developments in marine propulsion and, in conjunction with Faraday's principle of electro-magnetic induction, first propounded in 1831, to the large electricity generating stations that we know to-day.

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I—SOURCES OF ENERGY

Solar

Basically, most forms of energy are derived from the sun, and it is to the sun that we owe our physical existence. Although the amount of radiation reaching the earth from the sun is enormous it is difficult to concentrate it in sufficient amount to provide a large unit source of power. In an important indirect way this radiation is utilised in the absorption of sunlight in all green foliage. Carbon dioxide in the atmosphere and water in the air and earth are combined to form cellulose, starch and sugar. This process is called photosynthesis and but for it none of the higher forms of plant and animal life could exist.

Another natural process involving the indirect use of the sun's rays as a source of power is the evaporation of water from rivers, lakes and oceans and its subsequent precipitation as rain. This is the source of all inland water power.

The energy of the sun may be used directly to generate electricity, employing what are known as solar boilers or generators. Fig. 1 shows a design suitable for local supply. Small solar cookers are installed in India, and in many cases supplant equipment fired by animal wastes. More than 50 countries use solar energy to heat either water, clay or metals. It is also used to dry fruit and vegetables, and to heat houses and commercial buildings. The most powerful solar furnace yields temperatures of more than 3,000 deg. C. and is used to heat metals such as uranium and zirconium under contamination-free conditions. In arid zones devoid of normal sources of energy there are in use portable solar concentrators which can boil six litres of water or

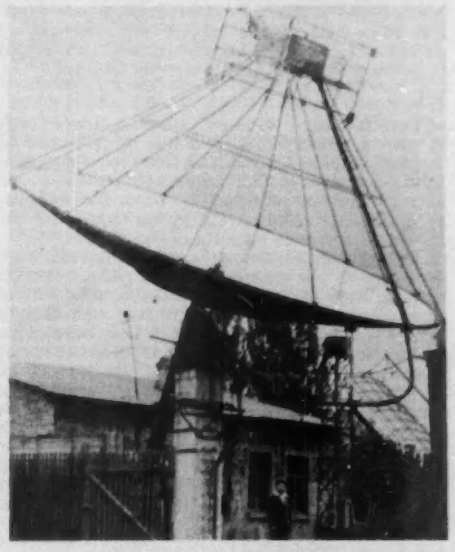

Fig. 1 — Solar generator suitable for a local electricity supply.

cook a meal for three people in an hour. The obvious barrier to general application in temperate zones is the prevalence of clouds which greatly diminish the available energy.

Geothermal Heat

Geothermal heat is available mainly in Iceland, Mexico, New Zealand, Japan and Italy. The last mentioned country is perhaps the leader in the application of this energy to electricity generation, and plant with an aggregate installed capacity of 400 MW is in operation in the districts of Larderello and Castelnuovo in Tuscany. In Iceland, although power is generated almost exclusively by hydro-electric means, more than half the houses in Reykjavik are heated by geothermal energy.

Wood

It is believed that about one quarter of the earth's surface is covered by forests and that the rate of growth is equivalent in heat value to some 1,000 $\times$ 10^6 tons of coal per year. In time past, wood ash was used as a fertiliser and the devastation wrought by burning large forests to give temporary improvement to soil fertility had a profound effect on several early civilisations. To-day, in India, wood and wood charcoal are still important fuels in industry, and, in Russia, wood and wood wastes are used in systems of combined steam generation and chemical processing. In fact, wood supplies about 7 per cent. of the world's energy requirements at the present time. In industrialised countries, however, wood is regarded more as a valuable raw material than as a fuel, and the use of wood and other vegetation for power production is likely to be restricted. On the other hand, wood is one of the few forms of energy that is inexhaustible if the amount felled does not exceed the rate of growth. The importance of afforestation continuing is obvious.

Coal

The world's coal resources are derived from the luxuriant vegetation which existed millions of years ago. This vegetation fell and decayed, and in time was buried and compressed by volcanic eruptions. Fig. 2 shows that coal is very unevenly distributed throughout the world. Most of the total world resources are thought to be in the northern hemisphere. With the exception of regions in Eastern Australia and the Union of South Africa, the southern hemisphere is practically devoid of coal. The total coal resources in the world are estimated to be $4{\cdot}5 \times 10^{12}$ tons but it would probably be uneconomic to mine more than about one third of this quantity. The annual consumption is $1{,}650 \times 10^6$ tons and this meets about 50 per cent. of the world's energy requirements. Coal is, and is likely to remain for many years, the most important source of energy.

Peat

Peat is found in important quantities in Scotland, Ireland, the U.S.S.R., and Sweden. It usually occurs in waterlogged bogs, its calorific value is low, and the evaporation of the moisture content is expensive where this cannot be done naturally by exposure to wind and sun. Much pioneering work is in progress to adapt plant to burn this type of fuel, of which that in Ireland is an outstanding example. In Scotland the development of gas-turbines for peat-firing is another example. There are steam power plants in Germany in which peat, brown coal and black coal can be injected simultaneously in pulverised form, whilst in Russia some 25 million tons of peat are burned annually in power stations.

Oil

The origin of oil is more obscure than that of coal. A current theory is that it is due to the action of tremendous pressure (resulting from volcanic upheavals) on organic matter deposited on the sea bed. Fig. 3 shows the principal oil fields and indicates regional reserves. Practically the whole of the known oil resources lie north of the equator.

As prospecting increases in volume and efficiency, estimates of oil reserves increase almost yearly, but the rate of increase is tapering off. Proved reserves amount to 26,000 $\times$ 10^6 tons, equivalent to 40,000 $\times$ 10^6 tons of coal. Oil and natural gas together amount to about 5 per cent. of the estimated world reserves of all fossil fuels. At present, oil supplies one-quarter of world energy requirements and natural gas about one-ninth. The demand for oil is growing at such a pace that there is likely to be a world shortage of natural oil long before there is a world shortage of coal. Indeed, as liquid fuel seems to be essential to our civilisation it will probably be necessary to manufacture it in quantity from coal within the lifetime of the present rising generation.

Wind

The energy of the wind is due to very recent heating of the atmosphere by the sun. As a source of power it has attracted attention for centuries and many small wind-power plants exist. The limitations are the irregularity of the wind and the rarity of the atmosphere which necessitates very large vanes to produce even moderate amounts of power. Because of the difficulties of harnessing this energy it remains doubtful whether it will ever supply any significant part of the world's requirements.

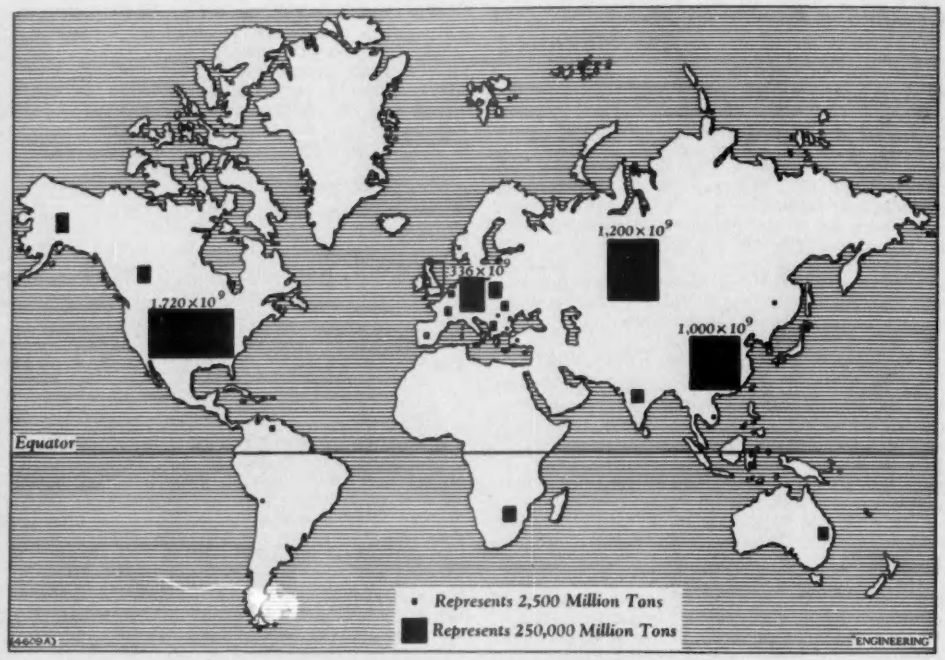

Fig. 2 Distribution of coal resources.

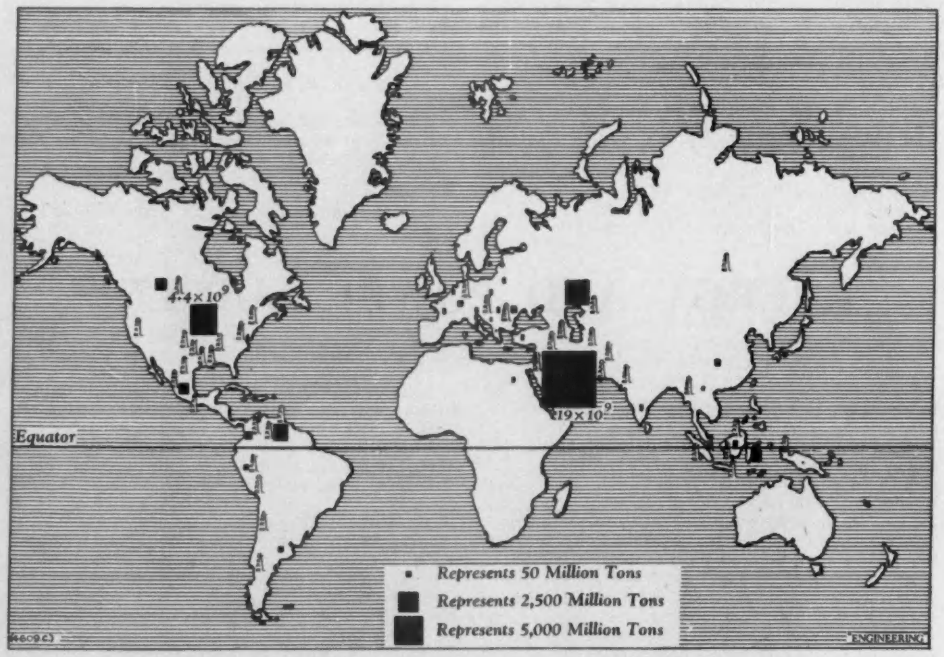

Fig. 3 Distribution of the world's proved oil resources.

Water

Fig. 4 shows the distribution of inland water power resources in the world, and it will be observed that a large part of the total is available in places remote from centres of population and industry, for example, in Africa and South America. Great Britain possesses less than 1 per cent. of the world potential of water power. At present the world gets 6 per cent. of its energy from hydro-power, but it is thought that if all the water power available could be utilised it would supply at least three-quarters of the present world need.

Utilisation of water energy on a large scale is almost entirely confined to the generation of power by hydro-electric means, and mention may be made of two notable installations. The Boulder Dam at Lake Mead on the Colorado River, although primarily conceived for flood control and irrigation, also provides low-cost power. The installed capacity is 1,300 MW and it is the second largest hydro-electric plant at present in operation, its output only being exceeded by the Grand Coulee Dam. Some 4,250 million units of electricity are produced annually. To put this figure in perspective, it represents two-thirds of the total sales to the 1,700,000 consumers in London during the year 1956/7.

The Dnieper Dam in Russia, when completed in 1938, had an output of 560 MW and was then the largest station in the world. During the 1939-45 war it was disabled by the retreating Russians and then destroyed by the Germans, after which doubts were expressed on the possibility of reconstruction. Nevertheless, work was started before the end of the war and the station was recommissioned in 1950. The installed capacity is now 650 MW.

Other large hydro-electric developments are taking place in the U.S.S.R. The stations being built at Kuybyshev and Stalingrad will each have an output of over 2,100 MW. Stations of 3,600 MW each are being built on the Angara and Yenisei rivers in Siberia.

Hydro-electric development is proceeding in the North of Scotland and to a lesser extent in North Wales, but the potential for exploitation in Great Britain is comparatively small, and the annual output can never amount to more than 2 million tons of coal equivalent.

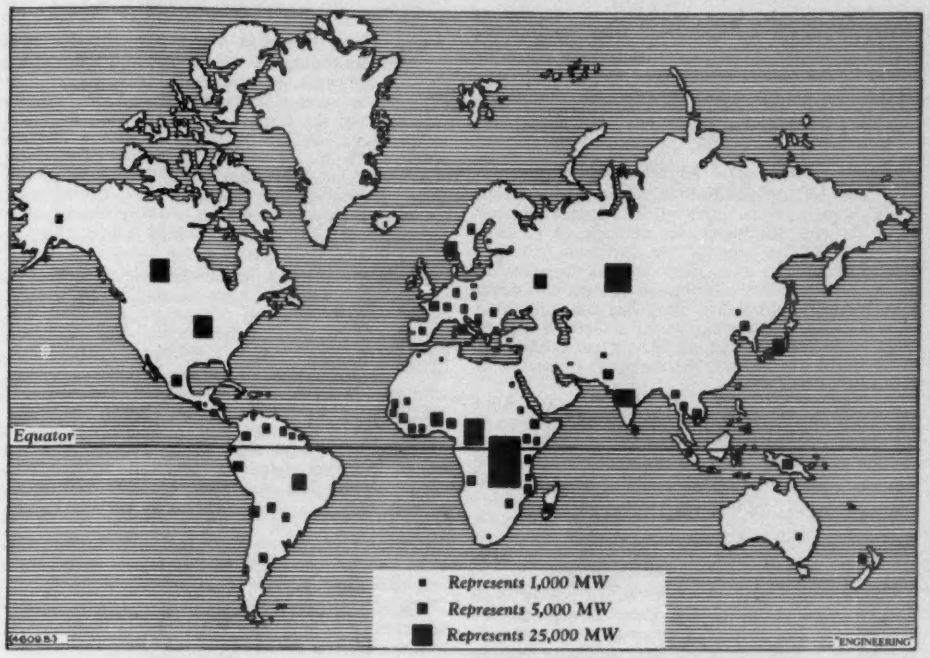

Fig. 4 Potential water power resources (based on minimum flow).

Tidal

Tidal power is in a separate category in that it is one of the few sources of energy which does not depend on past or present sunlight. It is an inexhaustible source of energy but the difficulty of application to power production is twofold. First, the utilisation of tidal waters requires the construction of large and expensive dams, and other civil engineering works of great magnitude; secondly, tides follow the moon whilst, in general, man's activities follow the sun, so that power from this source may be at its maximum when man is asleep. However, there are means of ameliorating this latter difficulty in industrial countries where the demand for energy is high and where facilities exist for transmission of the electricity so produced to the load centres. The development of pumped-water storage installations as described later may also provide a solution.

The proposal to erect a barrage in the River Severn has been the subject of three separate detailed investigations and reports were issued in 1933, 1945 and 1952. The last of these reports concluded that a single basin ebb-tide scheme having a maximum output of 800 MW was possible. A construction period of about eight years would be required. At that time (1952) the ratio of cost compared with a coal-fired station was three to two against the tidal scheme. There is also the problem of silting, and although tests have been carried out on models during the past few years this has still to be solved.

Electricité de France have embarked on a tidal power scheme at the Rance estuary, which will be the first of its kind in the world when it is completed in 1960. The scheme will have a peak capacity of 342 MW made up of thirty-eight 9 MW generators, and will provide about 800 million kWh a year. The most important feature is that an attempt is being made to secure a longer period of utilisation for tidal energy than was previously thought feasible. This advance has been due mainly to the development of the "bulb" generating unit, incorporating a horizontal shaft generator which is completely enclosed and situated within the dam itself. The generator is coupled to a Kaplan-type runner having blades that are adjustable through 180 deg. The unit can be used both for pumping and power generation, and can take the place of the conventional sluice gate.

The mode of operation is as follows, starting at full tide when the basin, i.e., the estuary, is filled. (If full tide occurs during a period of off-peak electrical demand the turbines may be used as pumps to fill the basin to a higher level than the top tidal mark.) As the tide falls away the turbines are used to generate power until such time as the head is too low. At this point the turbine blades are feathered to allow more water to flow seawards. Thereafter, the turbines act as pumps to reduce the basin level still further. When the tide flows on the seaward side of the dam, a correspondingly greater amount of power generation can take place because the water level in the basin is artificially low. The cycle described above is repeated for each ebb and flow of the tide.

Fig. 5 shows a cross-section through the dam and one of the bulb generating units.

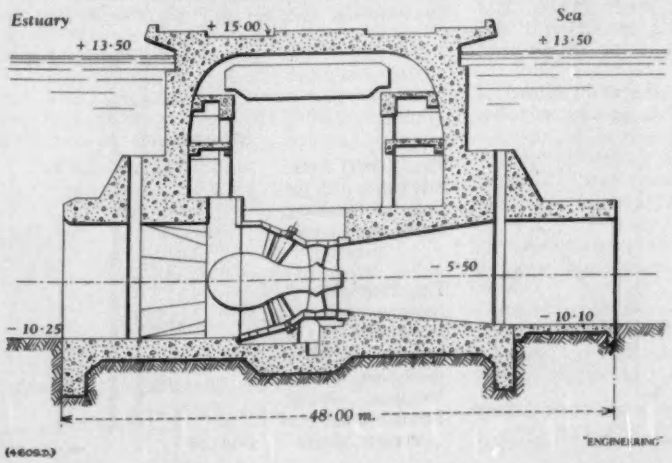

Fig. 5 Cross-section through the dam and generating unit for the tidal power scheme in the Rance estuary.

II—ELECTRICAL POWER IN BRITAIN

The electricity supply industry in Great Britain has hitherto been developed on the assumption that there would be sufficient supplies of coal available for its requirements. This assumption is no longer valid since Britain has changed from a coal-exporting nation to one that is heavily dependent upon alternative sources of energy.

It has been estimated that by 1965 the amount of coal equivalent required for electricity production in Great Britain will be 70 million tons. Present expectations are that the British coal available for this purpose will be only 53 million tons. Thus there will be a gap of 17 million tons. The growing scarcity of coal for the production of electricity in recent years has highlighted the necessity for improving thermal efficiencies so that the maximum amount of electricity may be obtained from each pound of coal burned.

During the past nine years, the electricity supply industry has saved over 31,000,000 tons of coal by increasing the average annual thermal efficiency of generation from 20·91 per cent. to 24·93 per cent. These efficiency figures take into account all the plant operated by the Central Electricity Authority, nearly 20 per cent. of which is over 25 years old, and would be considerably higher if the most modern stations only were considered; the 50 best stations of the Authority have an average thermal efficiency of 27 per cent., whilst the 20 best stations have an average of about 29 per cent. The Authority's latest stations operate at 31 per cent. thermal efficiency and stations now under construction are expected to reach thermal efficiencies of about 35 per cent.

The increases in efficiency have been achieved mainly by the use of higher steam pressures and temperatures, and by the increased size of generating plant. The economies that have resulted from the interconnection of generating stations have also been a material factor.

Following World War II, the deficit in generating capacity relative to demand was very marked because very little new generating capacity had been installed during the war years. It was deemed expedient, therefore, to instal as quickly as possible sets of 30 and 60 MW capacity which were then the standard designs. Such sets could be provided readily, and minimised demands on the design resources of a manufacturing industry already strained to the utmost in the effort to achieve a national post-war economic recovery.

After the immediate post-war period, when things had stabilised somewhat, the first step towards greater economy in generation was taken by the decision to order 100 MW units with steam conditions of 1,500 lb. per sq. in. and 1,050 deg. F. Further improvement in thermal efficiency was sought by reintroducing the reheat principle, first developed in Britain as long ago as 1920. Using the proposed L.P. cylinder for the 100 MW set, a new standard was evolved for a 120 MW set with steam conditions of 1,500 lb. per sq. in. and 1,000 deg. F. with reheat to 1,000 deg. F.

Then, as a result of the continued rapid rise in the demand for electricity, 200 MW units were developed using the next logical step in steam conditions of 2,350 lb. per sq. in., 1,050 deg. F./1,000 deg. F. and unit boilers of 1,400,000 lb. per hr. evaporative capacity. Three such stations have been programmed to date, with a total installed capacity of 2,400 MW. Future programmes will include a number of turbo-generators each of 275 MW capacity, representing a further advance on the 200 MW sets which are at present the largest on order for power stations in this country.

The Central Electricity Authority are also planning to instal, as part of their programme for 1962, a set having a capacity of 550 MW which is believed to be larger than any other unit at present projected anywhere in the world.

The decision to build a machine of this large capacity is the latest step in a development programme aimed at effecting reductions in the costs of generation by increasing the size of generating sets and boilers. Unfortunately, there is a factor outside the sphere of technical development which places limits on the size to which generator sets can be developed, namely the restriction on the maximum weight that can be transported by road. The maximum rating of generator which this limitation at present makes it practicable to contemplate commissioning is 275 MW. The 550 MW set will therefore be designed as a two-shaft cross-compound arrangement, employing two generators.

Whilst the 550 MW machine promises even greater economy in capital cost per kilowatt and in operating costs than does the 275 MW machine, each type has an important part to play in the Authority's generating system. For each type, the initial steam conditions will be 2,300 lb. per sq. in. and 1,050 deg. F. with one stage of reheat to 1,000 deg. F.

At the same time, work continues on even more advanced machines for subsequent programmes. Although no immediate justification has been found for a further advance in steam conditions, developments in materials and techniques can be expected progressively to decrease the incremental costs of higher pressures and temperatures, so that in due course higher thermal efficiencies may be economically achieved.

It is not possible in the space available to describe in detail all that is involved in the design of the main components of these large units, but the following

information for the 200 MW units will serve to show some of the main features of current designs.

TURBINE DESIGN

In one design of a 200 MW 3,000 r.p.m. machine, the first of which is to be commissioned at the High Marnham power station sometime in 1959, the high-pressure cylinder is of double shell construction for eight stages and single shell for four stages. The reverse flow over the inlet steam connections maintains moderate temperature differentials at the most complex part of the construction; the use of highly alloyed material is confined to the inner shell and the thickness of both cylinder walls is reduced.

The intermediate-pressure cylinder takes steam from the reheater at 441 lb. per sq. in. absolute and 1,000 deg. F., through interceptor valves. From the intermediate-pressure cylinder, which contains one of the three exhaust flows, two-thirds of the steam is carried by overhead pipes to the two-flow low-pressure cylinder. The three exhaust flows are connected to a single condenser bolted to a common exhaust flange.

The high-pressure and intermediate-pressure spindles employ integral disc construction, while the low-pressure rotors are built up from discs shrunk on to the shaft. A thrust bearing is located between the high and intermediate-pressure cylinders and longitudinal expansion of the shafts and cylinders takes place to either side of this bearing. Solid couplings are used to avoid such difficulties as the locking of flexible couplings that can occur with the heavy loads required to be transmitted.

Cylinder expansion takes place on the centre and front pedestals, each of which supports the respective cylinders on a plane near the centre line, i.e. in the direct line of thrust. The front pedestal houses a directly-driven centrifugal type main oil pump, helical-gear-driven governor, elements of the emergency unloading trip gear, and electrical and mechanical tachometers.

Blading material is conventional. Low-pressure blades in the last row are 27 in. long and have tip speeds of 1,400 ft. per sec.—about the speed of sound in the prevailing steam conditions. Reheat, by reducing the wetness of the steam at the exhaust, allows such speeds to be used without blade erosion becoming a serious factor.

GENERATOR DESIGN

Parallel development has taken place in the design of the electrical generator, by the adoption of new materials and by improved methods of cooling. A major factor has been the introduction of hydrogen instead of air for cooling purposes, and the adoption of inner cooling which brings the coolant into direct contact with the conductors. This has allowed a reduction in the amount of material used for a given output and has enabled the weight of a 200 MW stator to be kept within the transport limitation of 150 tons.

In order to permit of even larger outputs without increasing the dimensions of the machines beyond the limits of transport, liquid cooling of the stator windings is being adopted. A prototype machine employing water-cooled windings has been installed at the C.E.A.'s Bold power station. This machine is comparatively small (30 MW) but it is thought to be the first direct water-cooled generator in the world and will give valuable experience for the larger units under construction.

The winding takes the form of 12 hollow conductors through which the water flows, and the copper sectional area of these is only 56 per cent. of that of the normal air-cooled conductor for the same generator output and, by allowing a higher temperature rise, this figure could be reduced still further. Tests at 37·5 MVA have given a maximum temperature rise in the cooling water of only 2 deg. C. The power required to pump the water through the circuit was only 8·8 kW with a pressure drop of 18 lb. per sq. in. gauge across the winding.

BOILER DESIGN

With the rapid rise in output capacity, the ratio between the volume of the furnace and the surface area of the walls increases and hence the cooling effect of the water walls is felt less and less towards the centre of the furnace. Consequently, high gas temperatures tend to be produced at the furnace outlet. This has led to the development of partially and fully divided furnaces and, in the case of the boiler associated with the 200 MW set, to two combustion chambers, which materially assists boiler construction. A further advantage is that effective corner firing is made possible.

Although natural circulation is practicable, assisted circulation has been adopted in this design. Four specially designed pumps are provided, but two should be adequate for normal operation. At full load a boiler rated at 1,400,000 lb. per hour as used with a 200 MW set will use nearly 100 tons of coal per hour, and six pulverising mills will be provided.

With higher steam conditions and the use of reheat, the amount of heat absorbed in superheating the steam increases relatively to that required to evaporate the feed water. It becomes difficult to accommodate all the superheating surface in the convection zone and some radiant surface is used. This tends to flatten the boiler temperature characteristic, and to reduce the rate at which temperature falls off with load.

The twin furnace arrangement allows the secondary superheater to be placed at the exit of one furnace, and the reheater at the exit of the other, the primary superheater being common to both furnaces. This gives flexibility of control during starting-up and loading of the boiler. Steam temperature control is effected by tilting the burners, supplemented by spray attemperation of partially superheated steam. Gas recirculation is provided as an additional cover.

To be continued

Design

DATA ON HUMAN PERFORMANCE FOR ENGINEERING DESIGNERS

Continued from page 310

By K. F. H. Murrell, M.A., F.R.P.S.

INDUSTRIAL HEAT

Many industries have processes which make it necessary for operatives to work in heat. This is often uneconomic since the efficiency of the operative may be affected and frequent rest pauses may be necessary. In those situations where radiation is the main source of heat, shielding such as that suggested below is highly effective at low first-cost and the financial benefits can be very high.

Under normal conditions man maintains a constant body temperature so long as his regulating mechanism is working within its capacity. In this country the only industrial circumstance which is likely to impose stresses beyond this is exposure to radiant heat, for example from furnaces, and in warm-moist processes such as dye works or laundries.

The body gains its heat through convection, radiation and body heat production (metabolism) and loses it by evaporation, convection or radiation. This may be expressed as

$$E = M \mp R \mp C$$

where M, R and C = heat gain from metabolism, radiation and convection.

E = heat loss by evaporation.

Should the rate of evaporation be insufficient to dissipate the heat gained, the body temperature will rise. But before this occurs, heat strain may be manifest. There are a number of indications of heat strain. These will be an increase of blood flow to the skin surface with an increase in heart rate and in skin temperature, thirst, lassitude, and faintness. Since increase in heart rate is characteristic of heat exposure, older people are less well able to withstand heat due to progressive impairment of the cardiovascular function. This holds also for younger people who are suffering from heart trouble. If body temperature rises too much the regulating mechanism may break down and heat stroke will result.

The rate of evaporation depends upon the evaporation of sweat, which in turn depends upon the vapour pressure of the ambient air. In warm-wet environments the atmosphere is almost saturated with water vapour and the amount of sweat which can be evaporated is limited, and the tolerance of heat (whether this comes from the environment or from doing work) is correspondingly low.

Methods of Measurement

The amelioration of these conditions is a function of the ventilation engineer, though the design engineer can contribute by designing equipment or processes so that hot-moist air does not escape into the environment. For assessments of the tolerable environment and methods measurement the work of Bedford should be consulted.[26]

In hot-dry environments the main source of heat gain is radiant heat and the limit of tolerance is influenced by rate of sweating, and the sweat which can be evaporated is dependent upon the air temperature and velocity, the relative humidity and the mean radiant temperature of the surroundings.

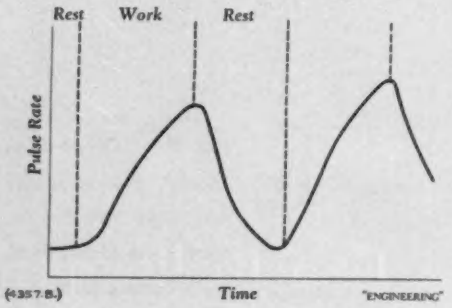

Fig. 28 (left) Pulse rate varies with the time of working, under hot conditions.

In general it may be said that if the actual task is not unduly heavy but nevertheless the operatives are taking rest pauses away from the source of heat, then the situation is worth investigating, on both humanitarian and economic grounds.

Often, it is quite obvious where the heat stress may occur even allowing for acclimatisation, in other instances it is not so obvious, and for determining whether action is necessary there are two main methods of measurement which may be used. Measurement on the operatives and measurement of the environment.

It has already been pointed out that one effect of heat stress is to increase the heart rate, if, therefore, this is recorded at intervals (by taking the pulse for 15 seconds) throughout the working period an assessment of the heat stress may be made. (See Brouha[28] and Christensen.[29])

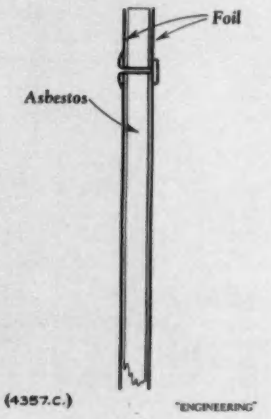

Fig. 29 (right) A recommended construction for screens for heat insulation is soft-tempered aluminium foil on asbestos cement sheet.

From commencement of work under very hot conditions the pulse rate will increase as shown in Fig. 28 followed by a recovery period when work ceases. If insufficient time is allowed for recovery, the next period of work will produce a higher figure and the pulse rate will steadily increase in a series of steps. If the heat is less, the pulse rate will increase more slowly and if the conditions are tolerable the increase may be quite small. As a general working rule any situation which increases the pulse rate by more than 45 beats per minute above the resting pulse rate will require some investigation. The shorter the period taken to reach this rate the more drastic the remedial action will have to be.

(Note: Ideally, physiological measures such as O_2 consumption or rectal temperature should be used but they have to be made by an expert. For simply deciding whether to take some action in a given situation pulse rate should suffice.)

The second method, that of measuring the environment is due to Hatch, Haines and Belding.[27, 30] This consists in determining the evaporation required (E_{req}) to disperse the heat gained through M, R and C and the maximum evaporation (E_{max}) possible under existing conditions of air velocity and relative humidity. Clearly E_{max} should exceed E_{req} if heat balance is to be maintained.

E_{req} is calculated from:

$$E_{req} = M + R + C.$$

Metabolism depends on the kind of work being done and for moderate work, standing with lifting or pushing is about 1,000 B.Th.U. per hour.

Haines and Hatch[30] have developed methods of estimating R and C and also the formula for E_{max}:

$$E_{max} = 10{\cdot}3\ V^{0{\cdot}4}\ (42 - VPa)$$

where

V = air velocity in ft. per minute.

Pa = vapour pressure of ambient air in mm. of mercury.

Belding and Hatch[28] have proposed a heat stress index:—

$$HSI = \frac{E_{req}}{E_{max}} \times 100$$

or, when $E_{max.}$ is greater than 2,400,

$$HSI = \frac{E_{req}}{2{,}400} \times 100$$

This may be considered either as a peak stress which can be tolerated for a short period or averaged over the working day as a means of determining the length of exposure time. It is suggested that most of the working population can tolerate heat stresses up to 30, although prolonged mild stress may affect alertness or the higher mental functions. On the other hand, physical work seems to be little affected unless it is already so heavy as to be near the maximum. More severe heat stress, 40 to 60, is likely to be tolerated only by physically fit men who are acclimatised. Mental work is likely to be affected but physical work can be undertaken by fit men. Severe stress of 70 or over can be tolerated by only a small proportion of the population and physical work is affected. It seems that, ideally, where heat stresses above 30 are to be found, rest pauses should be introduced to bring the average exposure down to or below this level. (It must not be assumed, however, that because this is done, that periods of activity in stresses of 70 to 90 can be tolerated.)

This can be expressed as:

$$\frac{HSI_W \times t_W + HSI_R \times t_R}{t_W + t_R} \leqslant 30$$

where

HSI_W and HSI_R = heat stress index while working and resting.

t_W and t_R = time of working and resting in hours.

If we assume an eight-hour working day and a final HSI of 30 this can be reduced to

$$t_W = \frac{240 - 8\ HSI_R}{HSI_W - HSI_R}$$

Fig. 30 The sleeve is attached only above the shoulder to allow for ventilation under hot conditions. Unfortunately, coverage is inadequate.

Fig. 31 By sewing the sleeve part of the way down the front, protection is increased without impairing ventilation.

As an example of the application of this method, consider a furnace room in which the following results were obtained:

Radiation	850	B.Th.U. per hr.
Convection	210	,, ,, ,,
Metabolism	1,000	,, ,, ,,
E_{req}	2,060	B.Th.U. per hr.

With the ventilation existing

$$E_{max} = 1{,}520, \text{ so } HSI_W = 136$$

When not working the operator was subjected to no heat strain and he lost his metabolic heat by negative radiation and convection, so $HSI_R = 0$ and the time of working (spread over 8 hours) is 1 hour 47 minutes. It will be seen that radiation is the main contributor to the heat load, and, when this was reduced by screening, the figures were:

Radiation	200	B.Th.U. per hr.
Convection	210	,, ,, ,,
Metabolism	1,000	,, ,, ,,
E_{req}	1,410	B.Th.U. per hr.

No change was made in air veolcity or relative humidity so E_{max} remained unchanged and $HSI_W = 93$ and $t_W = 2$ hours 35 minutes.

The ventilation was then altered so as to increase the air velocity with the result that E_{max} increased to 2,200 B.Th.U. per hour. Convection also increased due to more heat being taken up from the increased air stream.

Radiation	200	B.Th.U. per hr.
Convection	260	,, ,, ,,
Metabolism	1,000	,, ,, ,,
E_{req}	1,460	B.Th.U. per hr.

The HSI_W then becomes 67 and an operator can work for 3 hours 36 minutes out of 8 hours.

It should be noted that increasing the air velocity will make very little further improvement. The maximum amount of heat that can be lost by evaporation of sweat is 2,400 B.Th.U. per hr. and increasing air velocity beyond this point will make matters worse because it will at the same time increase the heat gain by convection.

The above is an outline of the method developed by Belding and Hatch. Those who wish to pursue the method further should consult the original papers.

Radiant Heat Screening

Heat, like light, is radiated in straight lines and it heats all parts of the surroundings on which it falls. It cannot be deflected by an air stream, but it can be stopped by screens. Any source which has a surface temperature above 200 deg. F. is probably worth screening.

The major improvement in the example above was obtained by screening, using polished metal which has a high reflectivity and low emissivity to radiant heat. Aluminium foil is the best material to use. It has an emissivity of about 0·03 compared with 0·07 for aluminium sheet or polished steel, 0·05 for polished brass, and 0·22 for stainless steel. In addition it is cheap and easy to handle.

A single layer of foil in contact with the emitter has an insulating value equivalent to 14 in. of cork. A recommended construction of screens is a layer of asbestos cement sheet, suitably supported, with sheets of 0·050 mm. soft-tempered foil fastened on each side by means of paper fasteners (Fig. 29). This gives an airgap between the foil and the asbestos sheet and is 25 per cent. more effective than when it is stuck direct on to the asbestos. It also allows corroded or damaged foil to be replaced quickly.

Furnaces should have semi-portable screens from floor to above head height running along their length with gaps left for doors which are in constant use. Adequate space should be left between the screens and the furnace for the removal of the heat reflected back from the screens. The doors themselves can either have screens mounted on them or be covered with foil stuck on with heat-proof adhesive.

Personal protection can be provided by loose fitting garments of aluminium faced fabric such as that made by I.C.I. Leathercloth Division. Garments made of this material should be loose fitting and should cover only those parts of the body exposed to radiation. Other parts should be uncovered to allow for ventilation. Particular attention should be paid to armholes. In Fig. 30 the sleeve is attached only above the shoulder to allow for under arm ventilation, but the coverage is inadequate and the clothing may catch fire. This has been remedied in Fig. 31 by sewing the sleeve part of the way down the front which gives protection without impairing ventilation. The collar is gusseted to bring it in front of the chin, otherwise the face may be burned by the heat rising from the front of the garment. Garments are not usually suitable where the radiation comes from all directions since, if adequate protection is to be afforded, the garment must cover the whole body and heat cannot get out. They can,

however, be used in exceptional circumstances such as repairing the interior of furnaces before they have cooled, provided the working period is short and precautions are taken to ensure that the operator comes out when he begins to feel too hot. Temporary protection can be obtained by supplying rolls of domestic foil which the operators can tear off and wrap round their hands or arms.

Attention should be paid not only to primary heat sources such as furnaces but also to stacks of cooling work. An ingot at 2,200 deg. F. will radiate 77,000 B.Th.U. per sq. ft. per hr. and this may well be more than the furnaces themselves. Portable screens or curtains of aluminium faced fabric should be installed.

As an example of the benefits which may follow from the installation of screens as described above, the case of men working between two billet furnaces may be cited. Before screens were installed men worked for only 7½ min. in every 30. (4 men to do one man's job.) After screens were installed (cost £35) one man worked for 30 min. and then did another light job of controlling for the other 30 min. The saving was thus 3 men per shift, or a saving of about £8,000 in wages over 3 shifts.

NOISE

Noise may have an effect in industry in three ways. Firstly, it may cause permanent deafness, secondly it may interfere with communications, thirdly it may reduce working efficiency. Although a great deal of research has been done on noise, many of the findings are contradictory and inconclusive. Nevertheless, they all point to the need for reducing noise as much as possible.

The Damaging Effect of Noise

Workers subjected to high noise levels over a long period of time may suffer impairment of hearing. Opinions differ as to how much noise over how long produces how much damage. Finding an answer to this question is made difficult because there is a wide variation in individual susceptibility to noise. The damage to the ear is not uniform over the noise spectrum and the first losses appear to be at frequencies of 4,000 c.p.s. and may be caused by excessive noise, not only in the octave of 2,400-4,800 c.p.s. but also in the octave 1,200-2,400 c.p.s. It is, therefore, not sufficient to measure the overall noise level in order to determine whether there is likely to be aural damage. A measurement should be made with an octave waveband analyser. Instruments for this purpose are available and one has been described in ENGINEERING.[26]

Fig. 32 sets out a curve for maximum permissible sound pressure level in decibels relative to 0·0002 dyne per sq. cm. suggested by Beranek and Parrack. Data given in a report published by the American Standard Association[25] suggests that levels rather lower than these should be used. It is also suggested that noise above these levels may cause hearing loss to some workers if they are subjected to this for an eight-hour working day, five days a week, for a period of about 10 years. It must be understood that these criteria are based on statistical analysis and cannot be considered as a sharp division between noise levels which are damaging and not damaging. They are at the best an average and do not take into account individual susceptibility and other variables. It seems advisable that where men have to work in continuous noise near these levels some measures to reduce the noise would have to be taken. This can by done by providing the worker with personal protection, by reducing the length of time of exposure, by reducing the noise level either by screening or by eliminating noise at its source.

Methods of Personal Protection

The two principal methods of affording personal protection are by means of ear muffs or ear defenders. These vary in their efficiency and may to some extent interfere with communication. The most efficient are likely to

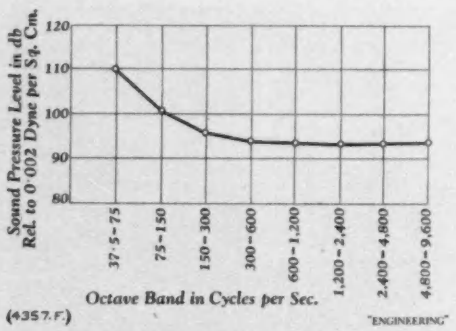

Fig. 32 The variation of maximum sound pressure level with frequency.

give an attenuation of the noise of approximately 25 dB, the attenuation being greater in the lower frequencies, particularly in the case of ear defenders. In general, therefore, this type of protection will be effective only in noise below approximately 100 to 110 dB and expert advice should be taken before this type of defender is used. For a fuller discussion of personal protection, see Michael.[32]

Time of Exposure.—It will have been noticed that it is not expected that damage will follow from an exposure above the noise levels given in Fig. 32 unless exposure continues for an eight-hour working day for a period of 10 years. It therefore follows that some measure of amelioration can be obtained by reducing the length of time that an individual is exposed at a noise above these levels. However, this should be resorted to only when all other measures have failed.

Noise Reduction.—Conduction of noise to the worker can be either ambient or by transmission through all the solid structures, particularly the factory floor. Ambient noise can to some extent be reduced by screening the noise source, by the use of acoustic tiles in noisy areas, or by insulating machines from the floor. The use of screens and tiles may reduce the noise by 5 to 10 dB, while total enclosure of the noise source with noise absorbing material can produce a reduction of up to 25 dB. Potentially, the greatest reduction of noise can therefore come from the initial design of the equipment and in this respect impact noise and exhaust noise merit the greatest attention. Measures which have been found successful in reducing impact noise include the design of punches so that they shear instead of giving a straight cut (this has also been found to increase tool life). Spot riveting 16 gauge mild steel sheets at 9 in. centres to the inside of chutes and tote pans reduces noise in the higher frequencies, as also does a layer of corrugated cardboard in the bottom of tote pans, covered by a sheet of 16 gauge mild steel, the addition of stiffeners to saw blades and the design of cams to avoid impact. A source of high frequency noise is the exhaust of pneumatic tools and this has been effectively dealt with by the fitting of miniature silencers. The noise of pneumatic hammers and similar tools can be reduced by the interpositioning of a nylon plug between the hammer and the bit, and this same principle has also been used on larger machines to reduce the noise of impact between two metallic surfaces. Noise, in such processes as barrelling can be reduced by lining barrels with, for instance, neoprene which has approximately three times the life of the bare metal. Noise can also be reduced by changing methods, for instance, the use of mechanical shears instead of chippers in fettling, the substitution of welding for riveting and so on.

To sum up, therefore, the following steps should be taken:

(1) A noise survey should be made of the plant, using an octave waveband analyser to ascertain which are the points at which potentially damaging noise may be experienced by the operator.

(2) The process should be examined to identify the source of the noise and whether possible steps should be taken to re-design the process along the lines indicated to reduce the noise, particularly in the high frequencies.

(3) If insufficient reduction has been achieved by these means, screening between the operator and the source of the noise should, if possible, be installed. Where possible, generators, pumps and similar unattended equipment which produce a "whine" in the high frequencies should be totally enclosed. Where the operator has depended upon the noise to determine whether the equipment is functioning correctly, a visual indication will have to be substituted.

(4) If the noise is still above an acceptable level personal protection should be provided for the operator or arrangements should be made for operators to work in the noise environment for only a limited period of time.

(5) In any event it is desirable that audiometric checks should be made by the medical department at not less than twelve-month intervals of all personnel employed in potentially damaging noise environment.

Noise and Communication

The effect of noise on communication may be as important as the deafening effect and may interfere with production. Interference with speech communication person to person, by telephone, loudspeaker and so on, can begin to cause difficulty, and speech may be impossible, at ambient levels above 95 dB when the signal-to-noise ratio is less than 10 dB. Telephonic communication can be aided by the use of acoustic booths or noise-excluding earpieces or headsets. Direct verbal communication can be aided by the provision of "quiet areas," that is, larger acoustic booths or rooms in which the communicants can stand. Ear plugs, when worn, can in some instances produce an improvement in hearing speech but the efficiency of the plugs varies.[33]

Noise can interfere with warning signals, gongs, hooters, etc., and also with knowledge of the correct running of a machine which an operator may derive from the sounds he hears. The object of a warning signal is to call immediate attention and to initiate action. If there is any likelihood of the signal being missed some other means should be substituted, usually a visual signal. Where the operator has to depend on hearing something happen in his machine in order to operate it efficiently, a remote indication that the event has occurred should be provided. (This is one of the places where the design of the machine may operate to the disadvantage of the older person.)

Noise and Efficiency

Results of research on the effects of noise on efficiency, particularly on mental work, are somewhat contradictory and are complicated by the possibility that if an individual decides that noise is going to affect his performance it may well do so. Distinction must be made between meaningful noise and white noise or continuous noise.

The distracting effect of a meaningful noise may bear no relationship to its loudness. A door banging or a mouse in the wainscot may be very distracting although the actual sound level may be quite low. In general any noise which is sufficiently obtrusive to attract the attention of a worker away from his work is likely to be harmful. This type of distraction is often found in large offices and may be more pronounced the quieter the office, but this must not be taken as meaning that offices should be deliberately made noisy in order to mask the loud-voiced individual on the telephone. There is, nevertheless, some evidence that some people work better in a moderate noise and this may be because it reduces distraction and perhaps gives a sense of activity.

There is some evidence that while noise above 85 dB may possibly cause a drop in performance in some people. In some jobs people may work harder in noise, thereby compensating for its effects. High frequency noise may be found irritating by some people and the sense of irrita-

tion may reduce their efficiency. Intermittent loud noises may interfere with efficiency at first but people seem to get used to them, though not if they are very irregular and only occur at infrequent intervals.

On first exposure to noise there may be some increase in bodily function such as pulse rate, respiration or basal metabolism, but these return to normal after a period of exposure. Opinions differ on whether intermittent noise will continue to produce these effects or whether they will disappear with continued exposure.

To sum up, it is likely that high level noise may interfere with the performance of some people. Moderate noise may improve performance in some circumstances. Distracting noise may produce an effect quite disproportionate to its loudness. On the whole the balance seems in favour of reduction of noise which is initially below damage level especially where mental work is being done.

To be continued

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Atomic Review

Power Plasma

Thermonuclear fusion was the subject of two papers read at the B.A. meeting at Dublin. Much of the material has already been mentioned in Atomic Review on January 11 and 25, 1957.

Energy Release from Fusion

Mr. J. D. Lawson, in a paper "Nuclear Fusion as a Possible Source of Power," considered the D-D reaction, together with the secondary reaction which consumes the tritium and He^3, and the tritium reaction in which a blanket of Li^6 is used. The reactions are shown in Table I.

TABLE I.—*Possible Thermonuclear Reactions*

Fuel	Reaction	Fusion products	Energy per deuteron burnt
H^2	$H^2 + H^2 \rightarrow He^3 + n +$ 3·3 MeV $H^2 + H^2 \rightarrow H^3 + H^1 +$ 4 MeV $H^2 + H^3 \rightarrow He^4 + n +$ 17·6 MeV $H^2 + He^3 \rightarrow He^4 + H^1 +$ 18·3 MeV (High temperatures only) At lower temperatures $He^3 + n \rightarrow H^1 + H^2 +$ 0·75 MeV (He^3 in absorbing blanket)	H^3 n He^4	7·2 MeV
H^2 Li^6 (in absorbing blanket)	$H^2 + H^3 \rightarrow He^4 + n +$ 17·6 MeV $n + Li^6 \rightarrow H^3 + He^4 +$ 4·8 MeV	He^4	22 MeV

Fig. 1 is a plot of the cross-section for the reactions (i.e. the target area presented by the nucleus) against a function of the relative energy of the bombarding particle. It will be seen that energies of tens or hundreds of kilovolts are required to produce high collision probabilities. The T-D reaction is the strongest, the He^3-D reaction is weak at low energies, but becomes important above 100 kV. It is not difficult to produce fairly intense beams of charged particles with these energies, and the most obvious way to obtain fusion reactions is to fire a beam of deuterons (deuterium nuclei) into a target of deuterium gas. If this is done, however, very few deuterons react with those in the gas, most being brought to rest by the transfer of energy to the orbital electrons in the gas atoms. The power release is quite trivial compared with that used to accelerate the deuterons.

Systems which make use of directed motion of the charged particles tend to be inefficient because the motion is destroyed by scattering before many reactions occur, and systems using charged particles only cannot be held together against the repulsive space-charge forces. From considerations of this sort one is soon led to the conclusion that any power-producing fusion reactor must be a thermonuclear reactor, that is, the reactants must be in the form of an electrically neutral gas in approximate thermal equilibrium. The reaction rate and hence power release in such a gas can easily be calculated as a function of temperature, by integrating the collision cross-section over the velocity distribution corresponding to a given temperature. Fig. 2 shows the power released per cub. cm. for a density of 10^{17} nuclei per cub. cm. for several fuels as a function of temperature. This density corresponds to about 1/200 atmosphere pressure at room temperature, but at 10^8 deg. C. this becomes some 3,000 atmospheres.

Fig. 2 also shows a curve giving radiation loss as a function of temperature. This radiated power is proportional to the volume of the gas and to the square of the density, and it increases as the square root of the temperature. Mr. Lawson remarked that at first sight this appears to contradict Stefan's Law, which states that the radiation is proportional to the surface area of the body and varies as the fourth power of the absolute temperature. The reason for the apparent discrepancy is that Stefan's Law only applies to systems in which the mean free path of the radiated quanta is very much less than the linear dimensions of the radiating body. In the ionised gas at a typical density of 10^{17} particles per cub. cm., this distance is of the order of kilometres. This is large compared with the dimension of any conceivable controllable reactor, though small compared with stellar dimensions. In the centre of a star, the radiation is trapped, whereas in a controlled fusion reactor it would all escape. Another way of stating this is to say that the gas is almost transparent, whereas Stefan's Law applies to black bodies, which absorb all the radiation which falls on them.

Since the radiation is a volume rather than a surface effect, the ratio of radiated to reaction power is independent of the geometry of the system; it is also independent of density, so that a unique "critical temperature" may be defined as that temperature at which the rate of energy loss by radiation equals the fusion power released. From Fig. 2 it can be seen that this temperature is of the order of 10^8 deg. for the D-D reaction (assuming that the tritium is burned as soon as it is formed, but that the He^3 is not burnt). For the T-D and D-He^3 reaction the corresponding temperatures are roughly 30 million and 1,000 million deg. respectively.

Kinked Tube

In a paper "Containment Problem for Thermonuclear Reaction," Sir George Thomson suggested that a thermonuclear reactor would not necessarily be a straight tube or a toroid. A kinked tube, shown in Fig. 3, might be used. His argument was that power would be extracted from a fusion reaction by taking energy from the magnetic field of the reacting plasma. The output magnetic field being at right angles to the driving field, it was an advantage to turn the plasma through 90 deg. in order that the energy might be extracted by the same circuits that set up the initial containing field.

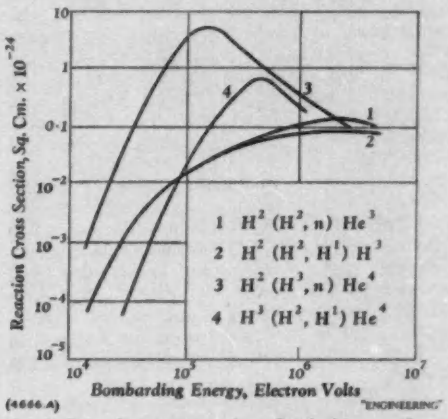


Fig. 1 Reaction cross-sections for fusion reactions.

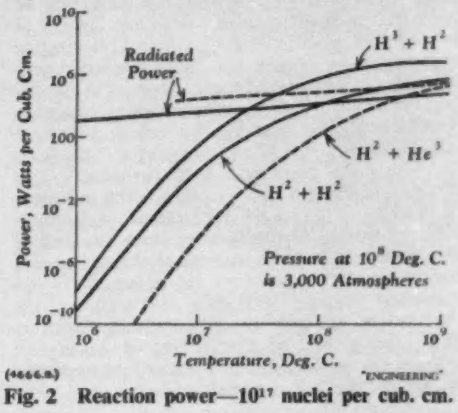


Fig. 2 Reaction power—10^{17} nuclei per cub. cm.

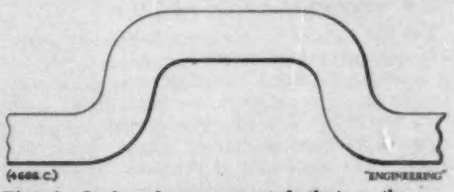


Fig. 3 It has been suggested that a thermonuclear reaction should be contained in a kinked tube rather than in a straight or toroidal one.

General Notes

Industrial Group Appointment

Following the appointment of Sir Christopher Hinton, K.B.E., F.R.S., as chairman of the Central Electricity Generating Board, Sir Leonard Owen, C.B.E., at present director of engineering and deputy to the managing director of the Industrial Group of the Atomic Energy Authority, has been appointed managing director of the Industrial Group of the Atomic Energy Authority from September 1.

Sir Leonard Owen, who is 60, has been engaged in the development of Britain's atomic energy programme since 1946, when he was appointed director of engineering on the production side by the Minister of Supply. In the

following year he became Assistant Controller in the Atomic Energy Division's production side.

Australian Uranium

The United Kingdom has been interested in the possibility of purchasing uranium made, by direct negotiations with mining companies operating in Australia. Contracts for the sale of substantial tonnages were signed with Mary-Kathleen Uranium Limited who operate the deposits near Mount Isa in Western Queensland, and with companies exploiting those in the South Alligator River area of the Northern Territory. All but a small part of the capital of M.K.U. is being provided from the United Kingdom (The Rio Tinto Company, Limited, of London is a major shareholder). Altogether some £10 million will be required for the development of the mine, erection of a treatment plant and township, with all services, and for the construction of roads; production of uranium oxide is expected to begin in 1959 and the value of output during the currency of the contract is expected to exceed £40 million. The A.A.E.C. consider that the British participation (the A.E.A. are reported to have lent over £6 million) will greatly benefit Australia, resulting in "an immediate inflow of capital and a substantial addition to national exports over a period of years, thus helping the Australian balance of payments." To safeguard its interests, however, and to encourage leaseholders and prospectors throughout the district, the Australian Government have stipulated that M.K.U. should treat in their plant a certain tonnage of ores purchased from other producers in the district.

The South Alligator River deposits have revealed some rich ore, but no company operating there has yet proved the existence of sufficient reserves to justify the construction of a treatment plant. The U.K.A.E.A. agreed to reserve a large market for oxide from this area if adequate ore reserves can be proved by the end of 1957, thus encouraging a vigorous prospecting programme. Meanwhile, the Rum Jungle deposits are being operated at "the level for which the plant had been designed." No production figures are available. The existence of reserves at Crockers Well, north of Radium Hill, in South Australia, has been established at a sufficient level to warrant the opening of a major opencast mine (to be operated by an unnamed foreign company) as well as the erection of a concentration plant at Crockers Well and a mill at Port Pirie. A survey of nuclear-energy development in Australia appeared in Atomic Review last week.

United Kingdom at Levant Fair, Bari

Exhibits typical of the latest British advances in nuclear power station design are being displayed in the official United Kingdom pavilion at the 21st Levant Fair at Bari, in Italy, being held from September 7 to 25. The display, which is designed to have a general appeal, has been organised by the Board of Trade in conjunction with the U.K.A.E.A. and in consultation with industry.

The display includes models of Calder Hall and the fast breeder reactor at Dounreay. The part which more than 1,000 firms throughout Britain have had in launching the new industry is emphasised by the display. A British film with an Italian soundtrack will show how a thermal reactor works.

Full Way Valve

In Fig. 4 is shown a 54 in. valve body for Calder Hall. It is for a full way valve designed and fabricated by Davey, Paxman and Company, Limited. The valve is constructed in B.S.S.14 steel to Lloyd's Class 1 requirements for a working pressure of 125 lb. per sq. in. at 700 deg. C. The test pressure was 250 lb. per sq. in.

East German Reactor

It is reported that a 2 MW water-cooled reactor is nearing completion at Rossendorf, near Dresden, in East Germany. The reactor was delivered by the Soviet Union; it employs partially enriched fuel.

Belgian Agreement

Two Belgian firms, Ateliers de Constructions Electriques de Charleroi (ACEC) and the S.A. Cockerill-Ougrée ironworks have signed a licence agreement with the Westinghouse Electrical International Company, which will permit them to manufacture and sell all the non-military types of reactors developed by the United States company.

Valid for a period of 15 years, the agreement grants to the licences the following rights.

(1) An exclusive right to manufacture in Belgium all types of reactors developed by Westinghouse for land, marine or airborne purposes;

(2) A right to sell in all parts of the world, except the United States and Canada, the types of nuclear power stations and equipments designed by Westinghouse;

(3) All specifications and "know-how" for manufacturing processes and test procedures;

(4) The right not only to send staff on information missions to Westinghouse, but also to delegate to the latter a number of engineers for a period of three years during which time they will work with their American colleagues on the design and manufacturing works in progress.

It should be remarked that the agreement leaves ACEC and Cockerill-Ougrée free to take part in the manufacture of other types of reactors than those designed by Westinghouse.

Photography Award

Mr. J. H. Jochimsen, chief Press photographer of the United Kingdom Atomic Energy Authority, has won the merit award for the most outstanding picture in the commercial category at this year's Professional Photography Exhibition. The photograph, "Remote Handling at Amersham," is on view at the exhibition, which is being held at the Royal Society of British Artists' Gallery, Suffolk-street, London, S.W.1. The exhibition was opened on September 6, when the merit awards were presented, and continues until September 17.

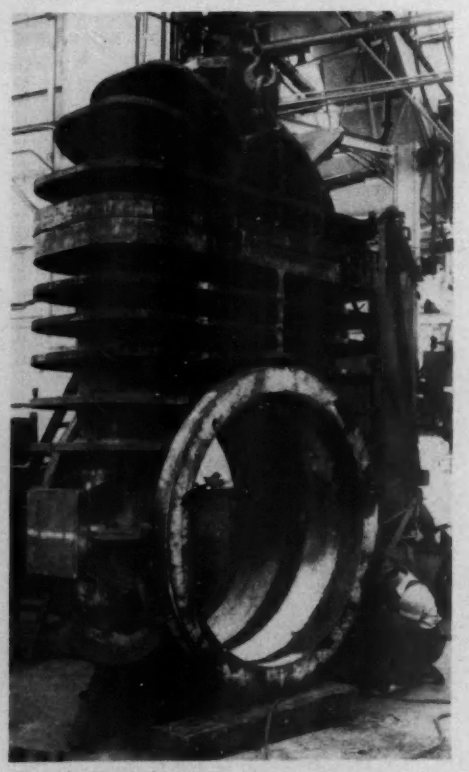


Fig. 4 The 54 in. valve for Calder Hall B is designed for a working pressure of 125 lb. per sq. in. and will form part of the gas-cooled circuit for one reactor.

Automobile Engineering

INFLUENCE OF TYRES ON MULTI-WHEEL DRIVES

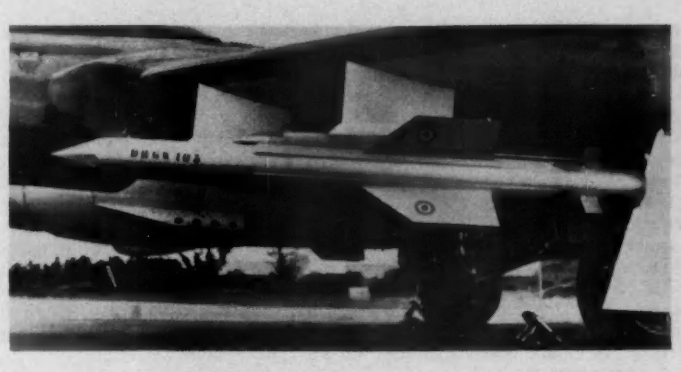
A paper, presented before the Institution of Mechanical Engineers by three members of the teaching staff of the Royal Military College of Science, Mr. W. Steeds, Mr. J. R. Ellis and Professor J. L. Thomson, gives the results of experiments with a two-wheeled rig arranged to produce wind-up and static and dynamic tyre test rigs.* It is well known that a four-wheel drive vehicle needs three differentials, one at the front, one at the rear and one in between if wind-up is to be avoided, but the disadvantage is that if one wheel loses traction all may do so, and it is usual in modern cross-country vehicles to omit the third differential. Various means have been proposed to overcome the difficulty, some of the Ferguson car patents concern the use of a differential in conjunction with two free wheels giving limited slip in either direction so as to lock up the drive when one output shaft tends to overrun the other beyond a predetermined rate.

Wind-up may be due to the fact that each wheel follows a curve of different radius on a corner, or to differences in effective rolling radius caused by variations in inflation pressure, tyre wear or loading. It may also be caused by differences in elastic properties of tyres arising from their construction or manufacture. Wind-up may continue until a negative or backward tractive effort is produced at some wheels which has to be overcome by the remaining wheels in addition to the normal resistance to motion. It might be concluded that wheels with a smaller static rolling radius would develop a backward torque equivalent to the slip between them and the road, but according to the authors this is rarely so. The maximum torques developed are determined by the characteristics of the tyres, and the effective rolling radius is a function of the torque applied to the tyres.

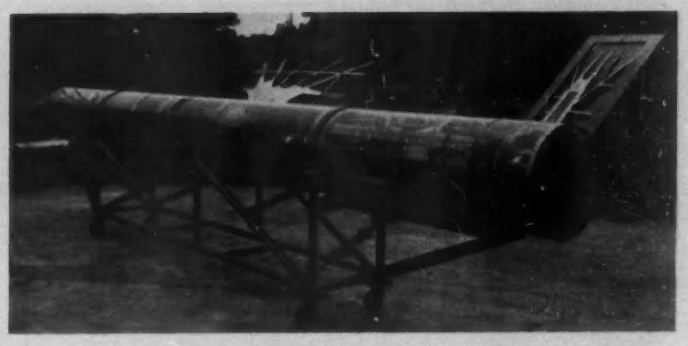
In a fully loaded four-wheel drive vehicle the rear-axle load is commonly higher than that on the front, and torque reaction under power increases this discrepancy. The rear wheels thus have a smaller effective rolling radius and wind-up occurs. The front wheels then have to provide a greater tractive effort to overcome it, hence the fact that front axles often run hot, a condition which can be alleviated by increasing the rear tyre pressure. It is held that fatigue due to wind-up accounts for many failures of front-axle transmission parts. In cross-country work opportunities frequently arise for release of wind-up; on the road it rapidly attains a limiting value at which point the tyres carrying the heaviest torque are deformed sufficiently to make all rolling radii the same. Rolling radius decreases as the transmitted torque is increased and the effect is greatest at small loads. Rolling radius increases with increasing rotational speed from speeds as low as 500 r.p.m. and the increase is greater with low-inflation pressures. Moreover, the rolling radius under free-rolling conditions is always greater than the static value. Tyres of the same make and type may vary appreciably in their free mounted diameter.

To minimise the effects of wind-up it is suggested that axle loads should be as nearly equal as possible and tyres should be selected to ensure equal free mounted diameters. Also, tyres with a lower torsional stiffness than existing designs would reduce wind-up by allowing a quicker change of effective rolling radius. Moreover, wind-up could be avoided altogether by deliberately making one pair of wheels of smaller radius and incorporating an overrun device so that they are normally overrun, but take up the drive if the larger wheels slip unduly.

* "Transmission Wind-up in Vehicles Having Several Driven Wheels," by W. Steeds, J. R. Ellis and Professor J. L. Thomson; paper presented to the Automobile Division of the Institution of Mechanical Engineers.



Firestreak, the air-to-air infra-red homing weapon, is seen here mounted on the Sea Vixen, for which it will be standard armament.



An early development round of Sea Slug, cut away to show the interior. This version was powered by a nitric acid/methanol liquid-fuel rocket.

THE AIRCRAFT INDUSTRY: GUIDED WEAPON SYSTEMS

Although security restrictions still prevent the release of much tangible information, the guided weapon exhibits on view at Farnborough were of interest for two reasons—firstly because Britain's national defence scheme will, from now on, be increasingly based upon their use; and secondly—and we hope in the long run that this secondary aspect will prove to be the more important—because the efforts that are now being directed to the perfecting of missile equipment are going to have a profound effect in the future upon industrial installations and domestic engineering. The vicious treatment that miniaturised electronic components, servo-mechanisms and instruments receive in the missile development laboratories—vibration, shock loading and atmospheric testing to a degree unthought of in ordinary commercial development—will, in due course, improve the breed of their industrial counterparts, and current industrial objections to the unreliability of sophisticated control gear and " black boxes " will no longer have justification.

First in the British field to perfect and produce a successful guided-weapon system was the Fairey Aviation Company, Limited, Hayes, Middlesex, whose beam-rider Fireflash is now in service as a training weapon on Swift 7 aircraft. The Fireflash weapon system has already been described in the August 23 issue of ENGINEERING; it may be recalled briefly that the radar beam which guides Fireflash to its target is generated within the parent aircraft, and is directed towards the target by the pilot's gunsight.

FIRESTREAK

A later air-to-air weapon system that has been ordered as standard equipment for the Royal Air Force and the Royal Navy is Firestreak, developed by de Havilland Propellers Limited, Hatfield. It employs an infra-red homing system, comprising a detector incorporating a Mullard infra-red cell which is sensitive to the rays emitted by the target aircraft; once the detector has been locked on to the target, it feeds signals into the control system to ensure that the missile follows the target's manoeuvres and eventually intercepts it. Since the parent aircraft in this type of system serves solely as a launching platform, it can break away as soon as the missile is fired. The infra-red system, which is said to be very sensitive and to operate at long range, has the advantage of immunity from enemy jamming to which radar systems are susceptible and which therefore necessitate complications in the circuitry.

Firestreak, which has cruciform wings and small control fins at the rear, uses no boost motors, propulsion being solely by a solid-fuel rocket motor within the cylindrical body, which is 10 ft. 6 in. long. The missiles are mounted in grooves on the underside of launching shoes attached to the wings of the parent aircraft. A typical launching shoe was on view on the stand of de Havilland Propellers Limited, and it would appear that there is provision for air supplies to be passed from the aircraft to the missile, and for electrical contact between missile and aircraft, which is broken when the missile, on launching, slides forward in the grooves.

Other interesting Firestreak components were on view, all by de Havilland, including a toroidal steel air bottle for pneumatic supplies, a twin " starter " valve incorporating what was probably a sequencing switch, a turbo-alternator and power-supply unit for the guidance and control circuits, and a rate gyro incorporating three air-driven gyros. The alternator and power unit developments by de Havilland Propellers Limited are particularly interesting: they are now supplying practically all British missile requirements (Thunderbird and Fireflash are exceptions). Developed from an R.A.E. prototype, the de Havilland alternator is made to extremely close tolerances and incorporates an electronic voltage regulator. It is available for use with a variety of prime movers—hydraulic, or turbines driven by air, cordite, isopropylnitrate or high-test peroxide. The Firestreak turbo-alternator is clearly air driven. Compressed air is also used, it is believed, for operating the control fins; and, because Firestreak is said to be a long-range weapon, but is compact in dimension, it seems likely that the control gyros are air-driven during flight, since there would be some difficulty in providing sufficient inertia for coasting, as is the case in the Fireflash and Bloodhound missiles.

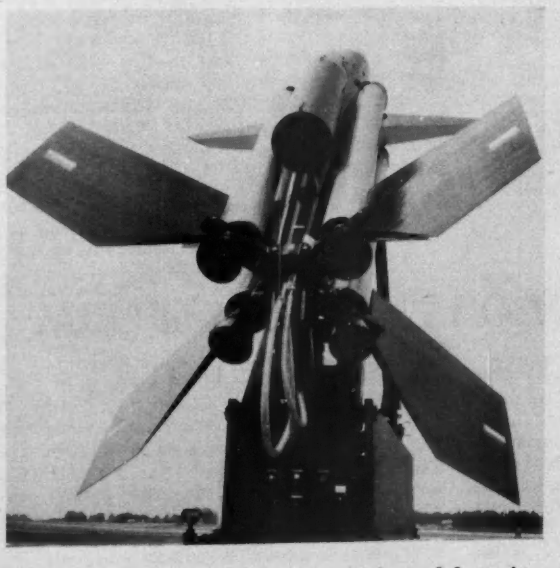
Aircraft which are to be fitted with Firestreak weapons are the R.A.F.'s Gloster Javelin and English Electric P1B interceptors, and the Royal Navy's Sea Vixen. The weapons are generally mounted in pairs, and can be launched singly or in unison, or jettisoned in emergency. In addition to the aircraft mentioned, the Saunders-Roe mixed-power experimental fighter also appeared at Farnborough, with Firestreaks fitted at each wing tip.

SEA SLUG

Early developments of the Royal Navy's Sea Slug sea-to-air medium-range weapon were shown by Sir W. G. Armstrong Whitworth Aircraft Limited, Whitley, Coventry, in the missile park and in the static display, the latter exhibit being cut away to show the internal arrangements. The configuration and structure of this early development are said to be identical with the production version, but no information could be obtained as to how far the internal arrangements were representative.

The version on view at Farnborough was shown with a nitric acid/methanol liquid-fuel sustainer rocket, but such propellants would not appear to be an ideal choice for shipboard use. This motor was situated at the rear end of the missile, and the propellants, housed in tanks in the centre part, were pressure-fed to the motor by cordite gas produced in a pressure generator in the nose. Cordite was also used to drive the turbine of a de Havilland turbo-alternator which provided electrical power for the auto-pilot control circuits and also the telemetering equipment.

No information on the production Sea Slug weapons has been disclosed



Bloodhound, the anti-aircraft weapon for home defence, is a semi-active homing weapon and is ramjet powered.

A Thunderbird development round leaves the "zero length" launcher, at R.A.E., Aberporth.

The Saunders-Roe experimental mixed-power aircraft, shown here without the Spectre rocket in action.

since the Admiralty release summarised in our June 14 issue. Briefly, it may be recalled that the missile is boosted by four wrap-round solid rockets at the forward end, which break away after supersonic speed has been attained.

Early warning radar detects the presence of enemy aeroplanes, and from a plot of their range, height and bearing a particular aircraft is selected as the missile's target. The target's range, course and speed are obtained from the missile guidance and control system and are used to position the triple-ramp missile launcher. The latter is automatically loaded from below deck. The electronic receiving unit has been developed by the General Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, and the servo controls by the Sperry Gyroscope Company, Limited, Brentford, Middlesex.

BLOODHOUND

Bloodhound, the surface-to-air guided weapon system that is expected to replace fighter aircraft for home defence, is now being produced in five factories for the Royal Air Force. It is also to be made available to the Commonwealth and NATO countries. Developed jointly by the Bristol Aeroplane Company, Limited, Filton, Bristol, and Ferranti Limited, Wythenshawe, Bloodhound is a complete weapon system employing a semi-active homing system, and is designed to withstand long exposures in all weathers on the launching site. It takes off from a launcher, designed by the Bristol Aeroplane Company and constructed by M. L. Aviation Company, Limited, White Waltham, which can be rotated through a full circle but has a fixed elevation of 45 deg.; a handling truck, designed by Bristol to facilitate rapid transport of the missile and erection on the launcher, is also made under subcontract by M. L. Aviation. The launcher, although anchored on site, can be readily dismantled for transport to another site on a standard Army truck.

The operation of the Bloodhound system is as follows: long-range early-warning radar locates the target and automatically brings into action a local narrow-beam illuminating radar at the nearest control station. The illuminating radar locks on to the target and, at the same time, causes the launcher to slew automatically towards the target, so that the missile is launched in roughly the right direction. Radar signals reflected from the target are received by the guidance equipment in the missile and its course is continuously computed, the necessary directions being passed to the missile control system to counteract the manoeuvres of the target aircraft.

The Bloodhound missile has an overall length of 22 ft. 2 in., a maximum body diameter of 1 ft. 9 in., and a wing span of 9 ft. 3 in. The main propulsion units are two Bristol Thor ramjets mounted externally in the plane perpendicular to the monoplane wings; these engines come into operation as the missile is boosted up to sustaining speed—more than 1,000 m.p.h.—by four wrap-round boost rockets, which fall away when burnt out. The choice of ramjet propulsion was influenced by the requirement for long range coupled with high performance—a long-range ramjet installation being appreciably lighter than a rocket. The missile, which weighs some 2,000 lb., is said to operate well into the supersonic region. An examination of the body structure suggests that materials and construction methods are fairly conventional, and it seems possible that the upper speed limit would be around Mach 2·5.

Control of Bloodhound is accomplished by varying the incidence of the main monoplane wings, using hydraulic actuators—a system which gives a particularly quick rate of response. The wings are moved differentially to bank the missile and, in unison, alter the pitch; fixed monoplane stabilising surfaces are attached to the rear of the missile body. The control gyros, as in Fireflash, are spun up to speed before launching and they coast during the actual flight.

The Ferranti contribution to Bloodhound comprises the guidance and control equipment, including complex pre-launch monitoring and automatic firing apparatus. Some of the components of the systems, which are still severely shrouded in security, were on view on Ferranti's stand—an electro-hydraulic control valve, a shorted-turn accelerometer, and examples of printed circuits. Although developed in the first place specifically for Bloodhound, Ferranti are now extending their printed circuit techniques for commercial applications such as computers, radio, television and other electronic apparatus.

The electro-hydraulic control valve has linear pressure/current characteristics, and may be used in a tractive system or in a servo mechanism employing electrical, hydraulic, and mechanical elements. The valve is said to be eminently suitable for such work owing to its inherently fast response, and the lack of coupling-back from its hydraulic system to the torque motor.

The accelerometer consists of a symmetrical laminated core. The centre limb carries an energising coil and the two outer limbs carry the secondary coil. A loop of copper forms the inertia mass, and is mounted on two restraining springs. Deflection of the copper turn makes the output of the accelerometer proportional to the acceleration. The range is $\pm$ 25*g* and it is designed to operate on a 20 volt 2,400 cycle supply.

THUNDERBIRD

Another semi-active homing anti-aircraft missile, in production for the Army, is the Thunderbird developed by the English Electric Company, Limited, Luton. As with the Bloodhound, Thunderbird's course is directed by the reflection from the target of a radar signal transmitted from a ground station. Thunderbird has been engineered for reliability and simplicity, and can be handled, transported and stored with the aid of existing army equipment. The use of a solid-fuel sustainer rocket means that no protective clothing is required by personnel handling the weapon. Thunderbird is of the conventional cruciform layout, with fixed main surfaces and controllable rear fins: four wrap-round rockets being used to boost the initial flight. It was the first British missile to be launched from a "zero length" launcher, and the illustration shows this launching taking place at the Aberporth range.

PILOTS STILL HAVE THEIR USES

Because the concept of 100 per cent. component reliability lies outside the experience of most practising engineers, there are many within the aircraft industry who believe that piloted supersonic military aircraft should still find a place in future defence plans and, therefore, the new supersonic interceptors were viewed with much interest—in particular the SR53, Britain's first "mixed power" aircraft, which provided a contrast in planform and dimension with the sharply-swept-back P1B twin-Avon-powered interceptor developed by English Electric Company. The P1B fighter, some details of which were given in the July 26 issue of ENGINEERING, page 123, has a span of 34 ft. 10 in., a length of 50 ft., and a height of 17 ft. 6 in. The corresponding figures for the SR53 are 25 ft. 1¼ in., 45 ft., and 10 ft. 10 in.

MIXED-POWER INTERCEPTOR

The philosophy underlying the use of mixed power—the rocket for bursts of high performance to and at high altitude, and the air-breathing engine for cruising—was outlined in last week's article. In the SR53 experimental interceptor, designed and constructed by Saunders-Roe Limited, East Cowes, Isle of Wight, the rocket engine, a de Havilland Spectre, is installed below the turbojet, an Armstrong Siddeley Viper. The intakes for the Viper engine are slightly behind and on either side of the cockpit. The wing, which has "squared off" delta planform, with a moderate sweepback, is not of extreme thinness. It houses the inwards-retracting main wheel units, and it is fitted with two-position leading-edge flaps for take-off and landing; conventional trailing edge flaps are also fitted. The tailplane is all-moving, supplemented by the elevator, and is set right at the top of the fin. The dive brakes, above and aft of the wing trailing edge, open out sideways from the fuselage.

The performance of the SR53 is still undisclosed—indeed, its constructors probably hardly know themselves yet, since it has only been flying some three or four months—but it has been stated that the airframe is of light-alloy construction and, therefore, for structural reasons it is not likely to venture far beyond Mach 2, although its thrust capabilities are considerably greater than this.

Construction

UNIVERSAL FLOATING PLATFORM

VERSATILE CIVIL ENGINEERING UNIT

The "Uniflote" floating construction unit, designed and made by Thomas Storey (Engineers) Limited, Vernon Works, Stockport, offers great scope for the construction of floating platforms of virtually any size or shape, and for many different purposes. Typical uses for the unit are for building landing stages, floating stages for harbour and bridge works, and floating platforms for pile drivers, boring equipment, dredgers and cranes. Such constructions can be permanent, or they can be of a temporary type, to be dismantled after use. The Uniflotes can then be used elsewhere, being easily transportable. In addition, any structure built of Uniflotes can be modified in shape or size at any time to meet changed conditions, and the units can be withdrawn, one at a time, for maintenance purposes. Bollards, anchors, fenders

Trial assembly of the Storey Uniflote landing stage before shipment to Nkata Bay port, on Lake Nyasa.

One of the many different forms of floating platform which can be built of Uniflotes is this raft for pile driving or dredging equipment.

and decking are available to enable any type of floating structure to be completed, ready for use. Scow ends can also be supplied, so that a raft or other assembly can be towed in the normal manner.

Designed originally to carry floating Bailey bridges, the Uniflote embodies the same principles of construction as the Bailey components, being jig built and completely interchangeable. Basically, the Uniflote is a steel-framed tank, with a welded skin, divided into three watertight compartments by means of bulkheads, and fitted with patented couplings on the ends and sides. The standard unit is 17 ft. 4 in. long, 8 ft. wide, and 4 ft. deep. It weighs 3 tons, and has a flotation capacity of 0·32 tons per in. of draught; this gives it an unloaded draught of 9 in. A superimposed load of about 12 tons is needed to bring the unit to submersion point. In still or near-still water the recommended free-board is about 6 in., which gives the Uniflote a carrying capacity of 10 tons. Two further depths will be added to make a range of three; the other dimensions will be the same as on the 4 ft. model.

EASY HANDLING

Protective runners are fitted to the underside of the Uniflote, and gunwales, mounted on the deck, provide a means of attaching various forms of superstructure and decking. Lifting eyes enable the unit to be picked up by crane. Each of the three water-tight compartments, to which access is gained through a deck manhole, is provided with hose connections for either flooding or compressed air ejection of water and the unit, once in the water, can be ballasted as required.

Couplers arranged round the sides and ends enable Uniflotes to be connected together side by side, end to end, or end to side, in any required pattern. These connectors are very simple, consisting of male and female lugs with coupling pins above water level, and special hooked lugs below the water. No underwater work is necessary in connecting one Uniflote to another or in breaking the connection. A slight tilt of one unit relative to the other, which can be achieved by one or two members of the erection crew walking to the end or side as required, enables the hooked connectors to come into line. The unit is then allowed to find its own level, and the top pins are pushed home and cottered, so making a rigid joint. There is provision for leaving a flexible joint at intervals in a long assembly, to allow of flexing in what would otherwise be an impracticable rigid beam.

TYPICAL ASSEMBLY

A floating landing stage built of Uniflotes, with a Bailey bridge approach, has just been erected for test purposes on a reservoir near the manufacturers' works, before being shipped to Nyasaland, where it will be used at the newly-developed port of Nkata Bay on Lake Nyasa. Lake cargo steamers of about 500 tons will use the port, and as the bed of the lake at this point is almost entirely of hard rock, the consulting engineers, Sir William Halcrow and Partners, Victoria Street, London, S.W.1, recommended a floating platform connected to the shore by a bridge, instead of the normal type of pier and wharf. The layout provides for one ship at a time to tie up at the outside of the landing stage. Goods will then be transhipped to barges lying alongside the stage, or else loaded into motor lorries and taken ashore.

Sixteen Uniflotes coupled together form the landing stage, which is decked with patented unit steel decking, and provides a buoyancy of 200 tons. Mooring bollards are fitted, and the stage, when it is re-erected on site with its Bailey bridge connection, will only need to have timber fendering and an asphalt covering added to be ready for use. The fendering and deck covering will be supplied and fitted by the local contractors at the Lake site, Johnson and Duckworth Limited, of Salisbury, Southern Rhodesia, who will also construct the timber trestle in the lake between the landing stage and the shore, to support the junction of the two bridge sections.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CREWE
"Science and Responsibility," by Dr. M. Pittock. Stoke and Crewe Branch. Royal Hotel, Crewe. Fri., Sept. 20, 7.30 p.m

OXFORD
Discussion on "Electric Railway Signalling." Oxford, Reading and Districts Branch. Regent's Park College, Pusey-street, Oxford. Sat., Sept. 21, 7 p.m.

SITTINGBOURNE
"Electrical Safety," by S. J. Emerson. Kent Branch. Shakespeare Hotel, Sittingbourne. Thurs., Sept. 19, 7.30 p.m.

YORK
"Earth Leakage Protection of Domestic and Industrial Installations," by J. A. Robbins. York Branch. Royal Station Hotel, York. Tues., Sept. 17, 7.30 p.m.

Engineers' Guild

LONDON
Annual General Meeting. Discussion on the aims and future policy of the Guild. Metropolitan Branch. Caxton Hall, off Victoria-street, S.W.1. Thurs., Sept. 26, 6 p.m.*

CARDIFF
Luncheon Meeting. South Wales and Monmouthshire Branch. Old Arcade Inn, Church-street, Cardiff. Fri., Sept. 20, 12.45 p.m.

Incorporated Plant Engineers

BLACKBURN
"The Fuel and Power Position in the United Kingdom," by Rear Admiral Sir Sidney Frew. Golden Lion Hotel, Blackburn. Thurs., Sept. 19, 7.30 p.m.

COVENTRY
"Titanium as a Material of Construction in the Chemical Industry," by Dr. K. W. J. Bowen. Birmingham Branch. Hotel Leofric, Coventry. Tues., Sept. 17, 7.30 p.m.

GLASGOW
Films on "Steam" and "Combustion and the Chain Grate Stoker," followed by a discussion. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Tues., Sept. 24, 7.15 p.m.

ROCHESTER
Film Evening. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Sept. 18, 7 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Films on "Steam" and "Combustion and the Chain Grate Stoker," accompanied by a discussion. Scottish Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Tues., Sept. 24, 7.15 p.m.

MANCHESTER
"Experience with the Heat Pump in Great Britain," by Miss M. V. Griffith. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Sept. 20. 6.30 p.m.

Institution of Highway Engineers

LONDON
"Pavement Construction on Christmas Island," by Major V. J. M. Smith and R. Airey. Institution of Civil Engineers, Great George-street, S.W.1. Fri., Sept. 20, 5.30 p.m.*

Institution of Locomotive Engineers

LONDON
Presidential Address by E. S. Cox. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Sept. 25, 5.30 p.m.*

Institution of Mechanical Engineers

FARNBOROUGH
Repetition of Thomas Hawksley Lecture on "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," by Sir Claude Gibb. Southern Branch. Royal Aircraft Establishment Technical College, Farnborough. Wed., Sept. 25, 7.30 p.m.

NOTTINGHAM
"Nuclear Reactors," by Dr. M. D. Wood. East Midlands Branch. Joint Meeting with the Graduates' Section. Engineering Building, The University, Nottingham. Wed., Sept. 18, 7.15 p.m.

SHEFFIELD
"The Work of the Standards Engineer in Industry," by H. Stafford. Yorkshire Branch. Royal Victoria Hotel, Sheffield. Wed., Sept. 25, 6.30 p.m.

Institution of Production Engineers

BIRMINGHAM
Film Evening. Birmingham Section. College of Technology, Gosta Green, Birmingham 4. Wed., Sept. 18, 7 p.m.*

LEICESTER
"Work Measurement and Its Uses for Management," by W. Hewett. Leicester Section. Grand Hotel, Leicester. Fri., Sept. 27, 7 p.m.

OXFORD
Discussion on "Transfer Pressing" (with film). Oxford Section. Town Hall, Oxford. Tues., Sept. 24, 7.30 p.m.

SHREWSBURY
"British Clock and Watch Production," by R. Lenoir. Technical College, Shrewsbury. Wed., Sept. 25, 7.30 p.m.

WOLVERHAMPTON
"Nimonic Presswork," by J. A. Grainger. Wolverhampton Graduate Section. College of Technology, Wulfruna-street, Wolverhampton. Wed., Sept. 18, 7.30 p.m.

Physical Society

LONDON
"Sound Propagation in Solids," by Dr. J. W. F. Bell. Acoustics Group. Physics Department, Imperial College, South Kensington, S.W.7. Thurs., Sept. 26, 5.30 p.m.
"Colour and Steelmaking," by Dr. B. O. Smith. Colour Group. Royal Photographic Society, 16 Princes-gate, South Kensington, S.W.7. Wed., Oct. 9, 3.30 p.m.

Women's Engineering Society

MANCHESTER
"Training and Opportunities for Women in Engineering," by Miss Anne Shaw. Manchester Branch. 46 Fountain-street, Piccadilly, Manchester. Tues., Sept. 24, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury, square, London, W.C.1. (LANgham 5927.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

The Human Element

A Sample Without Sir Winston

A paper given before the British Association by Mr. D. B. Bromley—" Some Recent Studies of the Effects of Age on Intellectual Processes "—provides some interesting material on the study of adult intelligence. It draws attention to the work of Lehman and Wechsler which seems to show that after 30 to 35 the rate of creative intellectual output tends to decrease, especially in quality. Such investigations have shown that the decrease is quicker in high-grade output than in low-quality work. Another investigation has shown that high-grade intellectual output falls with age but that low-grade output increases. Another finding is that older people not only tend to have fewer good ideas but also are less able to judge their worth. New learning and speed of response do not improve with age. Older persons also appear to be less able to deal effectively with the stream of information which comes to them on which their decisions are based. These findings would suggest that the older a man gets the less equipped is he, except in terms of experience, to take the decisions which become increasingly important as his seniority advances.

Mr. Bromley is cautious about the interpretation of such results. One pitfall, in particular, is worth comment. Investigations of this kind are concerned with averages and, unless the sample chosen is picked with great care, they throw up results which are relevant to the average or even to the mediocre but not to the outstanding individual. Quality of work may fall and output decline for the average person as age increases if the sample is taken wide enough, but there are sufficient examples of outstanding people whose capabilities remain unimpaired to a late age to suggest that it is one of those cases where averages can be very misleading.

Group Incentives

An investigation into the effectiveness of group wage incentives carried out in a railway repair works was described in a paper read to the British Association in Dublin last week by Mr. Leslie Buck. The research was centred on four groups, under the same foreman, employed on the servicing of passenger railway carriages. The results were inconclusive: two of the groups responded well, the other two did not. Those which responded were smaller and were distinguished by greater " membership stability " provided by a hard core of long-service workers. Mr. Buck's conclusion is that if the incentive value of a group payment system is to be increased, " it is not sufficient to consider only the characteristics of the system itself." The background of the groups themselves exerts a major influence on the results and, one suspects, so does the manner in which the change in method is explained and generally " put over."

Mr. Buck's paper aims to provide guidance to those who consider wage incentives as a desirable or even indispensable method of payment. For his own part, the author conveys the impression that he does not and that he has little sympathy for, or belief in, payment by results. The paper answers nothing clearly and leaves the reader more, rather than less, confused. This is not untypical of research into human relations: it is exceedingly difficult to establish principles or to generalise in a convenient and yet valid manner. But, as Mr. Buck points out, some 32 per cent. of all employees in British industry work under some form of payment by results.

In Fighting Mood

The Trades Union Congress held at Blackpool last week revealed new attitudes on the part of the leadership and a widening gap between the leaders and the Government. As one observer so aptly put it, in a comment on the change of personalities on the Council, " the distinction between the old and new guard is that while men like Sir Thomas Williamson are ready to trim their real opinions to sound respectable before the Socialist rank and file, men like Mr. Cousins feel like the rank and file but are ready to trim some of their speeches to sound respectable before Sir Thomas Williamson."

Much that was destructive, or at best negative, took place at the Congress. No one expects these occasions to be studded with new ideas or sudden departures from trends visible long before. To some extent, however, it is an occasion for the rank and file to express their " mood " and for the leadership to show how far it considers this mood to be practical politics. This year, the mood has not changed appreciably—if anything it seemed less aggressive—but Mr. Cousins' view of what is practical politics is much nearer Mr. Bevan's than Mr. Gaitskell's, while Sir Thomas Williamson was much more in step with Mr. Butler.

The rejection of the Pay and Prices Council, the veiled threat of strikes to secure their objectives, the refusal to consider any changes in the structure of the movement, and the general apparent lack of concern with the nation's economic affairs, make up a disturbing picture. The most hopeful feature, perhaps, is the warm reception given to the fraternal delegate from the United States, Mr. Walter P. Reuther, vice-president of the AFL-CIO and president of the United Automobile Workers. Mr. Reuther was able to show how well his union had done for its members—in terms of wages, pensions and a guaranteed wage—by accepting the advance of technology with open arms, and working within the framework of capitalism for a bigger share for the workers (and for consumers, too, through lower prices).

Harmony on Pensions

The Labour Party's " half pay at retirement " proposals have received the full support of the T.U.C. Somewhat surprisingly, and without a division, the Congress adopted Mr. Cousins' resolution that superannuation contributions and benefits should not be based on flat rates but on rates varying with earnings. Sir Alfred Roberts, the cotton workers' leader who heads the General Council committee on social insurance, denied that there were differences on this issue between the party and the unions, and called the plan " an imaginative concept, but certainly not Utopian."

Certainly the unions have been traditionally opposed to pensions which vary according to pre-retirement earnings and, equally, to a fixed pensionable age at which payment is automatic.

The implications of the plan, particularly those concerning the 8 million workers now covered by private schemes, were not fully discussed by the Congress. Sir Alfred Roberts indicated that specialised conferences would be held to discuss the matter and a detailed review of private schemes made in time for next year's Congress. This is a potential source of internal conflict, for some members will wish to continue their own schemes.

Where Labour Goes

During August the unemployment percentage at 1·2 per cent. of the employed population was the same as in August a year ago. There was a very slight increase in the percentage compared with July, a factor which is probably wholly seasonal. Even at the height of the holiday period, short-time working has been falling, and in July, the latest period for which figures are available, there was a further big drop. Also, there was a slight reduction in the number of vacancies unfilled early in August, compared with the month before.

At this time of the year changes in the pattern of employment are mainly seasonal, but even so, in July, as compared with the same month in 1956, the employment of labour was not very satisfactory. Compared with the year before, there were increases in July in numbers employed in transport and agriculture, vehicles, the food industries and miscellaneous services and the distributive trades. The main losses occurred in clothing and textiles and there was a slight fall in some engineering categories. Such indication as the figures at high summer may give suggests that the food and distributive trades are attracting more labour than the general economic situation justifies.

Hungarians Avoid Pitfalls

There are good reports of the Hungarians who have been admitted to the South Yorkshire coal pits. The number of collieries at which they have been employed is small and it may be that the refugees have been hand-picked but the reaction of the local people is favourable. The quality of their work is high and they have been found able to adjust themselves to the social environment of the coal-mining community. Only 130 men have been taken on so far but it is hoped to increase this to about 500 in another six months.

It is not likely that the testing time for this experiment is over yet. Suspicion of " foreigners " is deep-seated in isolated communities and trivial misunderstandings can be exaggerated to create an unfavourable impression. The next hurdle will be to deal successfully with these kind of misunderstandings when they arise—as arise they will. Much has been gained by this first draft into the mines for it has shown that Hungarian miners can work efficiently and without causing friction. That generalisation indicates that it is possible to use the successes achieved so far as an argument for other pits in South Yorkshire to experiment with foreign labour.

Disappointed Undergraduates

An article published in last week's issue of the *British Medical Journal* gives some interesting information on the results of a questionnaire sent round to a group of Cambridge male undergraduates. The sample consisted of 200 men.

Answers showed that 54 per cent. were disappointed with their time at Cambridge. The commonest source of disappointment was with fellow undergraduates. Nearly a half of the 54 per cent. accounted for this. About 20 per cent. complained of too little contact with senior members of the university. Other worries, among which were the lack of women, religious difficulties, and complaints about teaching methods and the like, accounted for between 4 and 6 per cent. each, but clearly came a long way behind the first two.

For most students, the change to residential university life is a fairly major personal adjustment in late adolescence. There are two immediate problems for the residential student. The first of these is to substitute a new set of relationships for those of school or home. The second is to substitute for the disciplined instruction of school life the self-discipline of the academic world. It is often that these two factors combined are a major reason for the failure of promising intellectual material to justify anticipation in academic work. It would be interesting to have a parallel investigation on non-residential universities and compare Oxford with Cambridge.

ENGINEERING
An Illustrated Weekly Journal

have you a coupling problem?

Errors in the alignment of connected shafts are, generally speaking, unavoidable. Even when exceptionally favourable conditions do permit of perfect alignment in the beginning, working loads must eventually cause misalignment. Wear of bearings and vibration are two certain factors which contribute to throwing connected shafts out of true, and even changes of temperature may vary alignments.

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